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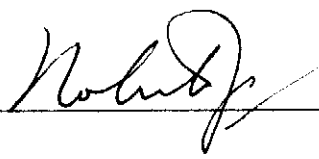
Signature : 

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WATER SENSOR SYSTEM (TRANSMITTER)

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Project Report Submitted as Partial Fulfilment
Of the Requirement for the
Degree in Bachelor of Electrical Engineering (Telecommunication)

FACULTY OF ELECTRICAL ENGINEERING
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Specially Dedicated to

My beloved Mother, Father, Sisters, Brother and Grandma

Thank you for the never-ending support, encouragement and inspiration

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ABSTRACT

The development of sensor networks requires technologies from three different areas which is sensing, processing and communication (including hardware, software, and algorithms). A sensor node basically is equipped by one or more sensor, small microcontroller, radio transmitter and receiver and finally an energy source. Overall this project explains the development of water level sensor in a wireless sensor network. Three different phases involved while developing this project which are sensor node hardware design, sensor node programming and as a final point the overall system development. The project began with the development of water level sensor, which is to sense 4 different level of water and send the data to the microprocessor. The microprocessor then processes the data and sends the data to the receiver. Meanwhile, at the receiver part, the data will be extracted and filtered. Finally the sensing data will be detected and processed to be display into the computer. Result and data are capture and analyze throughout the project to ensure the system function properly. At the end of the day, the entire project functions effectively. The transmitter node able to sense 4 deterrents water level and transmit the sensor data encapsulated with header, address and checksum to the receiver via wireless medium. While, at the receiver node, the sensor data was successfully extracted from the header, address and checksum. Then, the sensor data was transmitted to computer to display the current water condition.

ABSTRAK

Pembangunan rangkaian penderia mengadaptasikan teknologi daripada 3 bidang yang berbeza iaitu penderia, pemproses and rangkaian perhubungan (termasuk perkakasan, perisian dan algoritma). Pada amnya, nod penderia dilengkapi dengan satu atau lebih penderia, mikro pengawal, penghantar dan penerima radio serta bekalan tenaga. Secara keseluruhan, projek ini menerangkan tentang proses pembangunan penderia paras air yang beroperasi dalam rangkaian penderia tanpa wayar.tiga fasa yang berbeza terlibat dalam proses pembangunan projek ini iaitu pembangunan perkakasan nod penderia, pembangunan aturcara dan akhir sekali pembangunan keseluruhan system. Pembangunan sistem ini bermula dengan merekabentuk penderia paras air. Penderia ini mempunya keupayaan untuk mengesan 4 paras air dan seterusnya menhantar data yang telah diperolehi terus kepada mikropengawal. Manakala pada nod penerima pula, data yang dihantar akan diasingkan dan ditapis. Seterusnya data yang dikesan pada penderia di nod pemancar akan dikesan dan diproses untuk tujuan paparan pada komputer. Di sepanjang pembangunan sistem ini, setiap data dan keputusan akan dianalisis untuk memastikan keseluruhan projek berfungsi dengan baik. Secara keseluruhannnya, projek ini berfungsi dengan baik. Nod ini berjaya mengesan 4 paras air dan menghantar data yang telah ditambah dengan kepala dan alamat data ke nod penerima menggunakan medium tanpa wayar. Manakala pada nod penerima, data ini akan diekstrak dan hanya data dari penderia akan dihantar ke komputer untuk memaparkan keadaan air dari masa ke semasa.

TABLE OF CONTENTS

CHAPTER	TITLE		PAGE
	TITLE		**i**
	DECLARATION		**ii**
	DEDICATION		**iii**
	ACKNOWLEDGEMENTS		**iv**
	ABSTRAK		**v**
	ABSTRACT		**vi**
	LIST OF TABLES		**x**
	LIST OF FIGURES		**xi**
	LIST OF ABBREVIATIONS		**xiii**
	LIST OF APPENDICES		**xiv**
CHAPTER 1	**INTRODUCTION**		
	1.1	Overview	1
	1.2	Problem Statement	2
	1.3	Objectives	3
	1.4	Scope of work	3
	1.5	Thesis outline	4

CHAPTER 2 LITERATURE REVIEW

2.1 Wireless Sensor Network Overview 5
2.1.1 Basic concept of wireless sensor Network 5
2.1.2 Application of wireless sensor Network 6
2.1.3 Factors influencing sensor Network design 8
2.2 Radio frequency modules 9
2.3 Sensor network communication Architecture 10
2.4 Water Level Sensor 12

CHAPTER 3 METHODOLOGY

3.1 Introduction 14
3.2 Hardware Development 14
3.2.1 Sensor 18
3.2.2 Processor 21
3.2.3 RF Module 25
3.2.4 ISP Cable 26

3.3 Software development 29
3.3.1 Code development 34
3.3.1.1 WinAVR 34
3.3.1.2 PonyProg 36

CHAPTER 4 RESULT AND ANALYSIS

4.1 Hardware Development 38
4.2 Software Development 41
4.3 Measured Voltage 42

	4.4	Sensor data transmission	43
	4.5	Data Transmission between Sensors Nodes	44
		4.5.1 Wired transmission	44
		4.5.2 Wireless transmission	46
	4.6	Graphical User Interface	48
CHAPTER 5	**CONCLUSION AND SUGGESTION**		
	5.1	Conclusion.	49
	5.2	Discussion and Future Work	50
	REFERENCES		52
	APPENDIX (A – D)		54-77

LIST OF TABLES

TABLE	TITLE	PAGE
2.1	The OSI function	11
3.1	RCT-433-AS pin descriptions	26
3.2	ISP connector pin descriptions	28

LIST OF FIGURES

FIGURE	TITLE	PAGE
1.1	Flash flood incident in Johor Bharu	2
1.2	System development processes	4
2.1	Wireless sensor network applications	7
2.2	Non-Contact Water Level Measurement	12
2.3	High water indicator and low level water controller	13
3.1	Hardware development Flow chart	16
3.2	Wireless sensor network block diagram	17
3.3	Transmitter Node Block Diagram	18
3.4	Water Level Sensor Schematic Diagram	19
3.5	Atmega8535 pin configuration	22
3.6	Voltage regulator schematic diagrams	22
3.7	Microcontroller Board Schematic Diagram	24
3.8	RCT 433 AS transmitter module	25
3.9	ISP cable Schematic Diagram	27
3.10	Software development flow chart	30
3.11	Sensor reading flowchart	31
3.12	Transmitted data frame format	32
3.13	Data Transmission flow chart	33
3.14	WinAVR notepad and makefile window	35
3.15	PonyProg window	36
4.1	Processor board	39
4.2	Water level sensor	39
4.3	RF Transmitter modules	39
4.4	Water Sensor System Prototypes	40
4.5	ISP Cable	41
4.6	C Language program in WinAVR Programmer Notepad	42

4.7	Measured input voltage for processor board	43
4.8	Sensor data transmission (hyperteminal)	43
4.9	Sensor data transmission (oscilloscope)	44
4.10	Communication terminals for wired data	45
4.11	Observed data during wired transmission	46
4.12	Observed data during wireless transmission	47
4.13	GUI water level indicators	48

LIST OF ABBREVIATIONS

ADC	Analog to Digital Conversion
AVRGCC	AVR-GNU Compiler Collection
AVR RISC	AVR Reduced Instruction Set Computer
COM1	Serial communication port 1
CPU	Central Processor Unit
EEPROM	Electrically Eraseable Programmable Read Only Memory
FTP	File Transfer Protocol
ISP	In-Circuit Serial Programmable
KB	Kilo Byte
LSB	Least Significant Bit
MHz	Megahertz
MSB	Most Significant Bit
OS	Operating System
PPP	Point to Point Protocol
RAM	Random Access Memory
RF	Radio Frequency
Rx	Receiver
SLIP	Serial Line Interface Protocol
TCP/IP	Transmission Control Protocol/ Internet Protocol
Tx	Transmitter
UDP	User Datagram Protocol
USART	Universal Synchronous Asynchronous Receiver Transmitter

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	Transmitter node source code	54
	Transmitter node makefile	59
B	RF Module Data Sheet	66
	Atmel Atmega8535 block diagram	70
C	Graphical User Interface Result	71
D	Ponyprog Manual	73

CHAPTER 1

INTRODUCTION

1.1 Overview

Sensor network composes of large number of sensor nodes, which communicate with each other. Sensor network deployments were envisioned to be done in large scales, where each network consists of hundreds or even thousands of sensor nodes. These sensor nodes work by gathering their sensing information and sent the data trough the network using specific address. The main characteristic of sensor node is said to be physically small and inexpensive. Basically a sensor node consists of one or more sensor, a short-range radio transmitter or transceiver, a small microcontroller and a power supply in form of battery.

This project implements a water level sensor as a sensor node. The sensor node will communicate between the transmitter and receiver node using wireless transmission. The embed sensor will measure 4 different water levels and sends the data from the transmitter directly to the desired receiver. A wireless communication will be used throughout the project. This system consists of a microcontroller, RF transmitter, water level sensor and power supply.

1.2 Problem Statement

Water level sensor system was built appropriate with flood issue that hit our country every year. This issue forms many problems and trouble to the resident within the hit area. Most of them are left with nothing neither shelter nor property. Other than that, the wireless sensor network was chosen based on its performance. This system can be placed directly to the phenomena. Thus the precise data will be achieved. Figure 1.1 shows the latest flash flood incident that hit Johor Bharu reported in Berita Harian on November 1st, 2006. The aerial view of the phenomena showed the vehicles trapped in the flood at Johor Bharu.

Figure 1.1 Flash flood incident in Johor Bharu

Moreover the wireless sensor network operates in real time operation. Therefore this system is very convenient since data is transmitted and received at a specific time. Other than that, the rapid growth of wireless sensor network technology is also one of the reasons why this project was developed.

1.3 Objectives

The objective of the project is to create a sensor node that is able to do sensing processing and communicating between nodes. The sensor involved in this project is water level sensor. Most wireless sensor network developments are implemented close to the actual phenomena. The water level system is linked to a water level sensor so it can measure 4 levels of water before it reaches the maximum level. In order to apply this sensor, it must be placed near the riverbank. This sensor needs to be controlled by a microcontroller and the data might be sent via the wireless network. By completing this sensor node, perhaps it can perform accordingly to the design and present its task successfully.

1.4 Scope of work

In general, this project was divided into 2 parts; the transmitter and the receiver. Each part was developed separately and combined at the end of this project. The development of transmitter node consists of 3 main stages which are the hardware development, software development and finally a complete system development.

First and foremost, this project focuses on the development of a sensor node that can communicate wirelessly in wireless sensor network. Figure 1.2 shows the block diagram of the system development. First, it is necessary to get the overview and learn deeply this system functions. Next is the hardware development in wireless sensor network. Commonly, a sensor node consists of a microprocessor, a sensor, a radio frequency transmitter and power supply. Complete systems block diagram need to be designed and the step of work need to be planed so that the system will be implemented according to the schedule. After that, the sensor node requires the software development. The microprocessor needs to be programmed to ensure its function. It must be programmed according to the application.

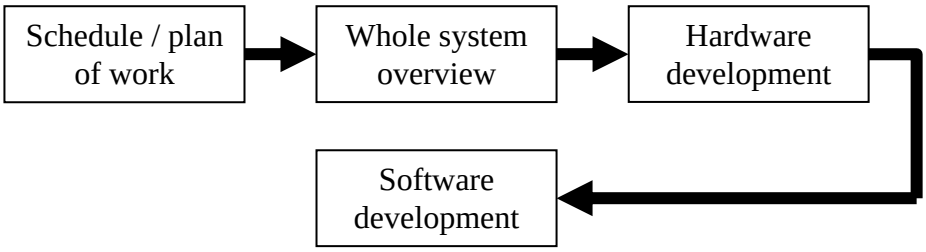


Figure 1.2 system development processes

1.5 Thesis outline

This thesis consists of five chapters. Chapter 1 briefly explains the development of water sensor system. It describes the reason of developing this system, the objective of developing water sensor system and as well as the scope of work involved while the system was developed.

Chapter 2 clarifies on the idea about the development of water sensor system. It includes the overview of wireless sensor network, the fundamental knowledge in TCP/IP protocol, design architecture and the alternative sensor to be chosen for the water sensor development. Then, Chapter 3 elaborates the process of completing the project. It explains the step by step work to complete the water sensor system which includes the development of hardware and software.

Chapter 4 discusses results and analysis of water sensor system. In this chapter, the results taken from the sensor node is analyzed. Data is captured using oscilloscope during data transmission. Finally, chapter 5 concludes the overall performance of the system and suggests the possible enhancement that can be done to improve the wireless sensor network performance.

CHAPTER 2

Literature Review

2.1 Wireless Sensor Network Overview

Wireless sensor network describes accumulate numbers of nodes within an area. It consists of distributed sensors to monitor physical or environmental conditions, such as water level, temperature, sound, vibration, pressure, motion or pollution taken at different locations. Wireless sensor network development is originally inspired by military application such as battlefield surveillance. The sensor nodes represent significant improvement compare to ad hoc sensor. The major difference is in sensor networks the sensor can be placed directly to the phenomena. Sensor network also allows the deployment in inaccessible terrain.

2.1.1 Basic concept of wireless sensor network

Most sensor node application aims at monitoring or detection of a phenomenon. Sensor nodes are densely deployed either inside the phenomena or very close to it. It can be an advantage to get the actual precise data compared to the conventional sensor. Examples of sensor node application includes weather forecasting, humidity detector, wind speed detector, earthquake detector by reading the vibration of earth surface, water level sensor for flood prevention, forest fire detection and wild life habitat monitoring.

Another unique feature for sensor node is its mobility and it can be remotely monitored. To achieve this remote access monitoring, sensor node can be connected to an existing network infrastructure such as the global internet, local area network or private intranet. Since the sensor node is equipped by on board processor, instead of sending the raw data to the node responsible for the fusion, sensor node uses its processing ability to locally carry out simple computation and transmit only the required and partially processed data.

2.1.2 Application of wireless sensor network

The range of wireless sensor network usage can vary from ecological to social applications in everyday world. Figure 2.1 shows some examples of sensor network applications which can generally be categorize as military applications, environmental applications, Health applications, home applications and other commercial applications. In the military application, the implementation of wireless sensor network is the best idea since sensor networks are based on the dense deployment of disposable and low-cost sensor nodes. Destruction of some nodes by hostile actions does not affect a military operation as much as the destruction of a traditional sensor, which makes sensor networks concept a better approach for battlefields [11].

Similar with the implementation of wireless sensor network in the battle field, implementing the wireless sensor network for environmental application might be very helpful. Some examples of environmental applications of sensor networks include tracking the movements of birds, small animals, and insects; monitoring environmental conditions that effects may harm the surroundings such as forest fire detection, flood detection and precision agriculture.

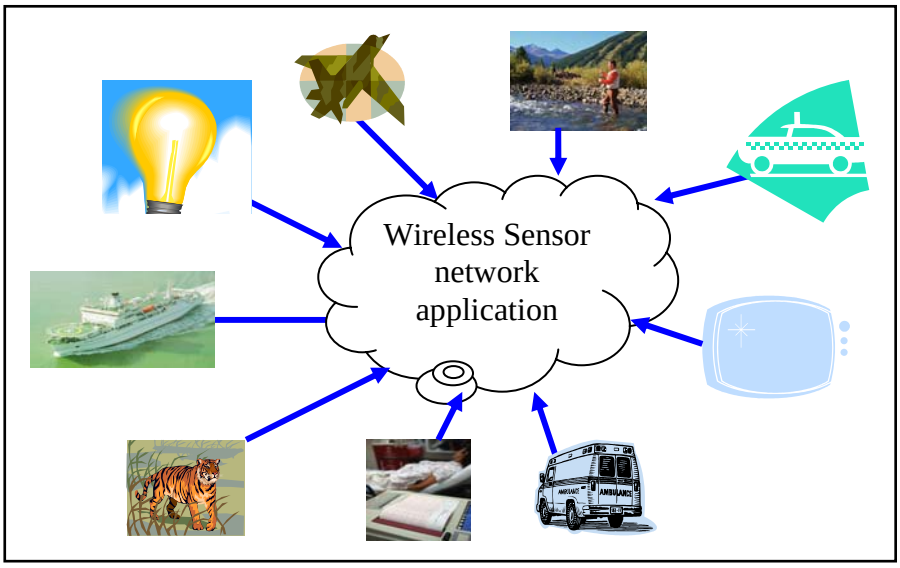


Figure 2.1 Wireless sensor network applications

Other than environmental applications, employing the wireless sensor network for health application can be very useful. Some health application based on wireless sensor network provide interfaces for the disabled, integrated patient monitoring, wireless diagnostics, remote drug administration in hospitals, monitoring the movements and internal processes of insects or other small animals, telemonitoring of human physiological data, and tracking and monitoring doctors and patients inside a hospital.

With the rapid growth in technology, applying wireless sensor network for home appliance is one of the best ideas. A smart home technology demands a tiny node to be implemented directly to home appliance and help the owner manage their home devices remotely. The other implementations for wireless sensor network are the commercial applications such as monitoring material fatigue, building virtual keyboards, managing inventory; monitoring product's quality, constructing smart office spaces and environmental control in office buildings.

2.1.3 Factors influencing sensor network design

The factors that drive the design of sensor networks and sensor nodes also cannot be neglected. These factors are important because they serve as a guideline to design a protocol for sensor networks. In addition, these influencing factors can be used to compare different schemes [11]. Sensor network design can be influence by numerous factors includes fault tolerance. Fault tolerance is the ability of wireless sensor network to sustain network functionality without any interruption due to sensor node failure [11]. Low fault tolerance is required for low interference environment and vice versa. The other factor is production costs. Cost of each sensor nodes has to be kept low. The cost should not be above than Bluetooth and satellite technology.

Besides cost, a hardware constraint is also the main factor that influences sensor network design. Sensor node is made up of four basic components including sensor, microprocessor, radio frequency module and power unit. The implementation processor board is depends on the application or sensor used by the sensor node. Environment also can be the main factors that influence the sensor node design. The sensor nodes can directly deploy to the actual phenomena. It also may work in remote geographic areas. The sensor node can also work under high pressure in the bottom water, in harsh environment and also under extreme heat and cold. So, the correct component must be selected to ensure the performance of the sensor node.

The next factor is the transmission media. Wireless sensor network is linked by a form of radio frequency module, infrared or optical media. Various transmission medium enable global operation of these networks worldwide. For example the radio frequency module and a variety of modulation technique can be used to be implemented in the wireless sensor network. The selection of the modulation technique also is depends on other factors discussed previously. Various frequency bands are available for sensor nodes applications. The last factor that influences the design of wireless sensor network is power consumption. The wireless sensor node can only be equipped with a limited power source. One of the examples is the 3-9 V

battery sources. In some application scenarios, replacement of power resources might be impossible. The sensor node lifetime strongly depend on battery source.

2.2 Radio frequency modules

Radio Frequency modules are partially complete circuits that can be incorporated into larger designs. RF modules include receivers, transmitters and transceivers. RF modules employ numerous dissimilar modulation technique and radio system. An examples of modulation technique used in RF module is Phase-shift keying (PSK) which is a digital modulation scheme that conveys data by changing, or modulating, the phase of a reference signal (the carrier wave). Other examples are amplitude modulation (AM), Frequency modulation (FM), Amplitude shift key (ASK), Frequency shift key (FSK) and Phase shift key (PSK).

The numerous modulation techniques have their description. On off key, it can be described as a binary form of amplitude modulation. Other than that amplitude modulation explains as a technique used in electronic communication, usually for transmitting information using a carrier wave wirelessly. Amplitude modulation works by varying the strength of the transmitted signal in relation to the information being sent [9].

Next is the frequency modulation technique. FM is a form of modulation which represents information as variations in the instantaneous frequency of a carrier wave. In analog applications, the carrier frequency is varied in direct proportion to changes in the amplitude of an input signal. Digital data can be represented by shifting the carrier frequency among a set of discrete values, a technique known as frequency-shift keying [7].

Besides FM, the other modulation technique is frequency shift keying. Frequency shift keying is a digital modulation scheme that conveys data by changing, or modulating, the frequency of a reference signal (the carrier wave).

Meanwhile the Amplitude-shift keying (ASK) is a form of modulation which represents digital data as variations in the amplitude of a carrier wave. And finally Phase-shift keying (PSK) is a digital modulation scheme that conveys data by changing or modulating the phase of a reference signal.

2.3 Sensor network communication architecture

Sensor network may operate in different geographic areas and in any unsecured environment; therefore security should be built into the design. Network techniques are needed to provide low-latency, survivable, and secure networks. Low probability of detection communication is needed for networks because sensors are being envisioned for use behind enemy lines. For the same reason, the network should be protected against intrusion and spoofing [12].

The approach to design protocols for sensor networks is driven by the requirements of the physical layer. The protocols should be developed according to the choice of physical layer components, such as the type of micro-processors and the type of RF modules [11]. The approach of the wireless sensor node also highlights the importance of the application layer, network layer, MAC layer, and physical layer to be integrated with sensor nodes hardware. Sensor network protocol has to be aware of the hardware and able to use special features of the microcontroller and transmitter to minimize the sensor node’s power consumption.

Those approaches to design the protocol describe how data communications should take place. In OSI model, each layer performs the function required to communicate with another system. Every layer provides service for its higher layer. Table 2.1 validates the function of every layer in OSI Model.

Table 2.1 The OSI function

Layers	Function
Application	Provides access to the OSI environment for user and also provide distributed information services
Presentation	Provides independence to the application process from difference in data representation (syntax)
Session	Provides the control structure for communication between applications; establish, manage, terminate the connection between cooperating systems
Transport	Provides reliable transparent transfer of data between end points; provides end to end error recovery and flow control
Network	Provides upper layers with independence from the data transmission and switching technologies used to connect system; responsible for establishing, maintaining, and terminating connections.
Data Link	Provides the reliable transfer of information across the physical link; sends blocks (frame) with necessary synchronization, error control and flow control
Physical	Concerns with transmission of unstructured bit stream over physical medium; deals with mechanical, electrical, functional, and procedural characteristics to access the physical medium

This system deploys the first 2 bottom layer of OSI model which consist of Data link and Physical layer. Non- standard protocol is implemented for the system for communication. Physical layer provides the electrical and mechanical interface to the network medium which is represented by the wireless link. By providing the interface, it offers data-link layer the ability to transport a stream of serial data bits between two nodes in the system. The physical layer is also responsible for making sure that the bits are safely sent from one place to another, by considering other factors such as modulation technique, and deals with the electrical characteristics of the wireless link.

2.4 Water Level Sensor

For the environment application, variety choices of water level sensors have been manufactured and produced. These water level sensors mostly employ a high technology system to measure a very accurate level, for examples ultrasonic water level sensor produced by Global Water Instrument, INC. The system uses the latest ultrasonic distance measuring technology for accurate non-contact water level monitoring.

The fully encapsulated sensor/transmitter is temperature compensated and provides an industry standard 4-20 MA output. There are three ranges available including 1', 3', 6', and 35' to meet a wide variety of applications. The unique 1' range ultrasonic water level sensor is ideal for measuring flow in small flumes and weirs. The 3' and 6' ultrasonic water level sensor ranges are best for measuring river, lake and tank levels and for measuring open channel flow in larger flumes [10]. Figure 2.2 shows the non contact water level measurement by Global Water Instrument.

Figure 2.2 Non-Contact Water Level Measurement

Besides ultrasonic technology, water level alarm sensor by Global Water is also a unique choice. It is a solid state water sensor for detecting the presence of conductive solutions, such as water spills, water tank levels, and drainage ponds. The water alarm sensor features two stainless steel electrodes that are positioned at a desired point for liquid detection. When fluid is detected, a relay closes in the water level alarm and the signal can be used to sound an audible alarm or close a switch inside a piece of remote monitoring equipment. The relay output is fully isolated and can handle 2 amps of current.

If the water level alarm sensor sense in a dry conditions, the detection sensor will automatically reset without requiring additional service. The water level alarm is rugged and durable and requires minimal maintenance. The water level alarm has many uses, including surface water monitoring, precision level detection, water level control, high water indication, and submersible marine low level indication [10]. Figure 2.3 shows the high water indicator and low level water controller that can be implemented as the alternative sensor for this system.

Figure 2.3 High water indicator and low level water controller

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter describes the method used in order to complete water sensor system. It consists of the design process of water sensor system. The development of water level sensor has been made possible by a number of technological developments including the miniaturization of electronics and sensors. Generally the design processes are divided into three phases. They are the initial electronic design or the hardware development, sensor node programming or the software development and the final phase, the overall system testing development. In order to achieve the objectives of this project, it is important to figure out what is the finest technique and proper step in designing the sensor node. The microcontroller circuit should suit best the sensor implementation to achieve the greatest performance during transmission.

3.2 Hardware Development

Figure 3.1 gives an idea about the steps followed in order to finish this project. The initial state is about getting the brief idea about what is wireless sensor network, what components each node in the network consist and finally distribute these nodes into transmitter and receiver part. The project is then divided into 2 parts which is the transmitter and the receiver part. In the transmitter part, it is essential to

choose the appropriate sensor to be developed in the project. The sensor application must be suitable with the microprocessor so that the program written for the sensor can be fit into the microprocessor memory. Other than that, the output voltage from the sensor also must be within the microprocessor range which is 4.5-5.5 volt. It is important to keep the voltage level within the range because at this range the microprocessor will work efficiently. If the sensor voltage level is out of range, microprocessor may not detect the signal sent by the sensor.

In figure 3.1, the next step after selecting the appropriate sensor is sketching the system block diagram. System block diagram illustrates each part on the system development. It gives the brief idea on the water sensor system development. Next is the water sensor and microcontroller circuit design using multisim software. Then the circuit is simulated using the same software to ensure that the circuit is free from error.

After completing with the circuit design, the project continus by assembling the circuit on the test board. Then the circuit is tested using multimeter and oscilloscope. Sensor circuit is tested to obtain the suitable voltage level according to the microprocessor's operating voltage range. Other than that, the microprocessor board must be tested to ensure that it receive the stable input voltage. Stable input voltage refers to the steady voltage value supplied to VCC pin. It is essential to obtain this level to make sure the microprocessor performs efficiently and to avoid any error from occurring during data transmission.

Hardware designing is the critical phase in this project. Any failure on the hardware part will affect the overall system. A troubleshoot and redo work must be done if any error is detected during the hardware development process. The final step after hardware development is software development. This phase involve a few software which will be discussed in detail in the next topic in this chapter.

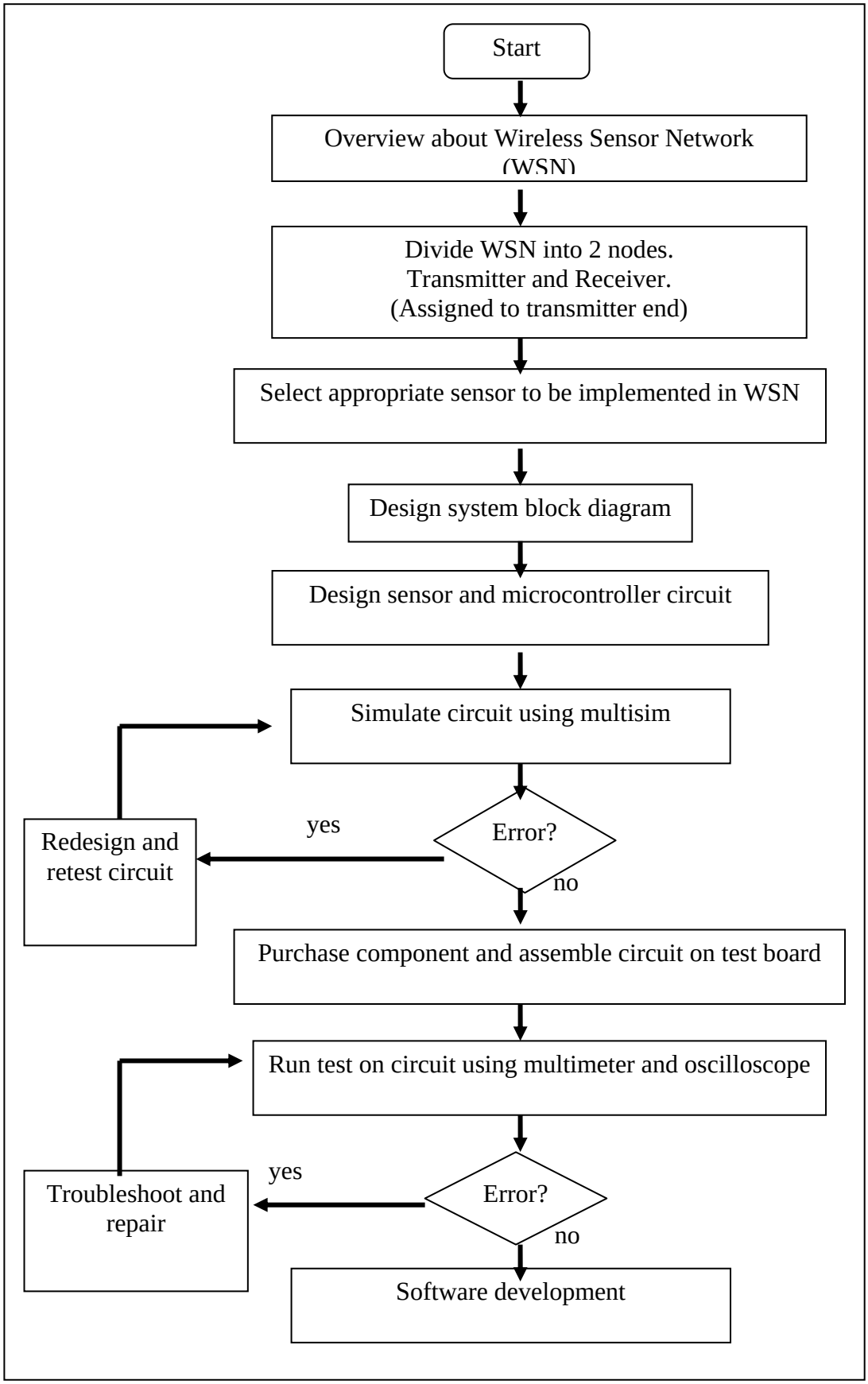


Figure 3.1 Hardware development Flow chart

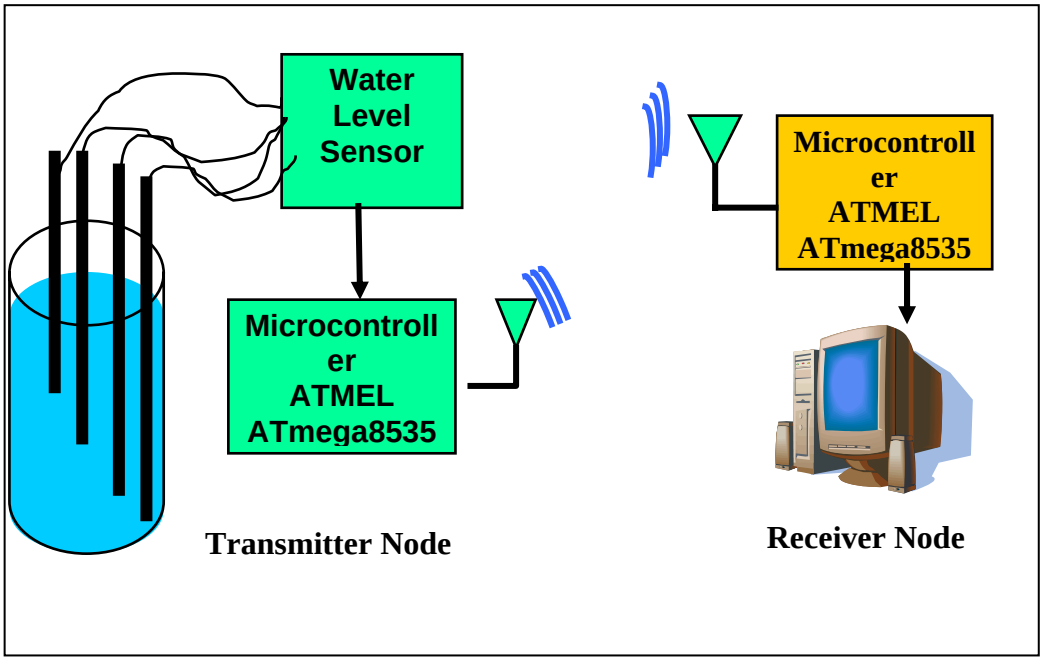


Figure 3.2 Wireless sensor network block diagram

The network block diagram is showed in figure 3.2. As shown in figure 3.2, a set of wireless sensor network consist of 1 unit of microcontroller at each part, radio transmitter and receiver, one or more sensor depending on the application and as well as energy source. Microcontroller is the main component for each node in sensor network. Microcontroller is used to process data sense from the sensor; send the data through the network and to extract data that have been received.

As mention before, in the transmitter part, it is essential to select the suitable sensor to be implemented in and communicate in the network. Water level sensor was selected due to the current issue regarding flood and the profit loss by the flood victim.

Transmitter node block diagram which include a sensor, radio frequency transmitter and a Microcontroller is shown in figure 3.3. Water level sensor was linked to Port A, Radio frequency module connected to Port D and ISP cable as the code downloader was connected to Port B.

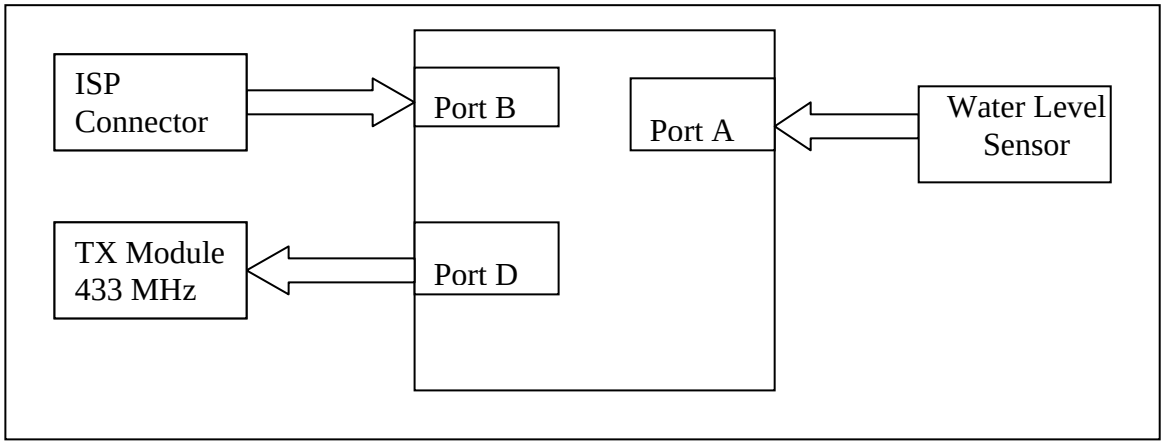


Figure 3.3 Transmitter Node Block Diagram

Transmitter node design consists of water level sensor schematic circuit and microcontroller schematic circuit. Both sensor and microcontroller schematic circuits are showed in figure 3.4 and figure 3.7. Data from sensor is linked to the microcontroller board by a direct wire. The microcontroller then processes the data captured by water level sensor and as a final step the data is sent over the network using radio frequency transmitter that operates in 433MHz.

3.2.1 Sensor

Sensor can be described as any device that receives a signal or stimulus and react to it in a distinctive manner or in other words sensor is an electronic device used to measure a physical quantity such as temperature, pressure or loudness and convert it into an electronic signal of some kind (e.g a voltage). Sensors are normally components of some larger electronic system such as a computer control or measurement system. Analog sensors most often produce a voltage proportional to the measured quantity. The signal must be converted to digital form with an ADC before the CPU can process it. Digital sensors most often use serial communication such as RS-232 to return information directly to the controller or computer through a serial port.

Parts List

Generally the sensor circuit consist the following components:

IC1 = IC2 = 14 pin D4011BC, 2 input NAND get

R2 = R3 = R6 = R7 = 470 ohm resistor

R1 = R4 = R5 = R8 = 180K ohm resistor

D1 = D2 = D3 = D4 = 4148 diode

Probe = any object that can conduct current.

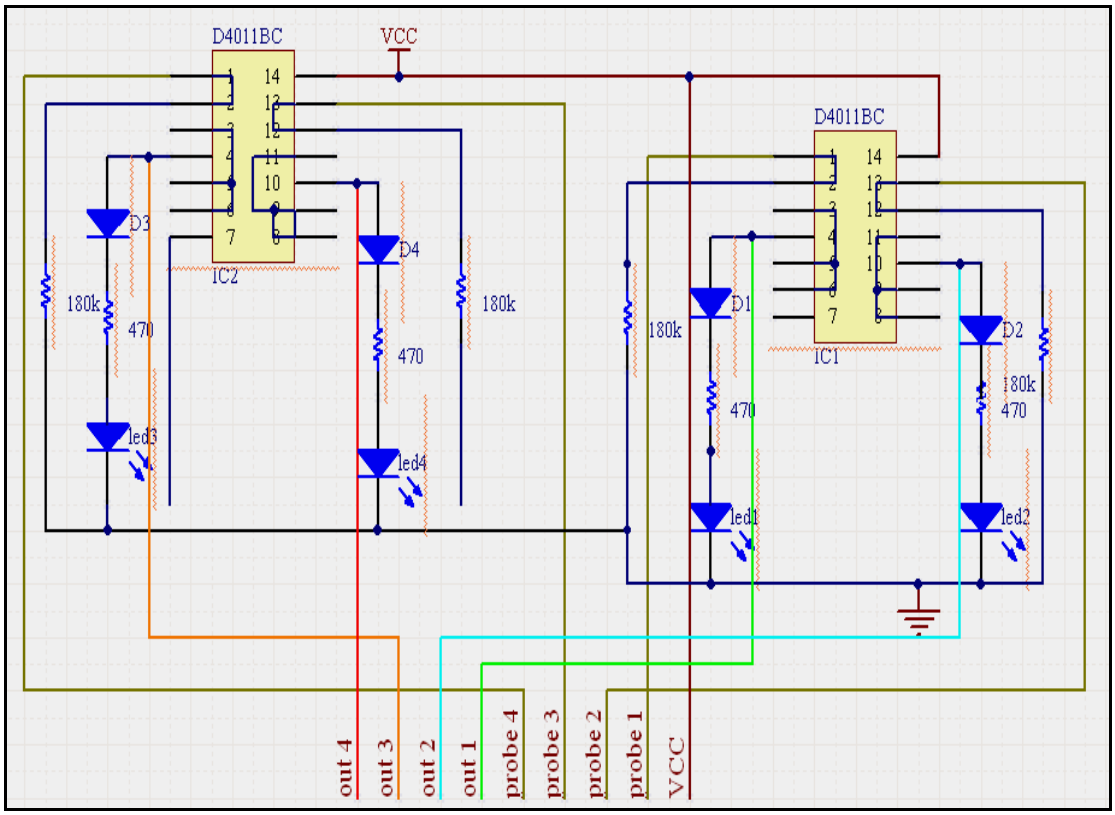


Figure 3.4 Water Level Sensor Schematic Diagram

In this system, water level sensor is designed with a simple but reliable circuit to detect the existence of water at 4 present limits. Figure 3.4 shows the sensor setup. The component used during the sensor development are 14 pin 2 input NAND gate (D4011BC), 4 units 470 Ohm resistor, 4 units 180K Ohm resistor, 4148 Diode and 5 probes. 4 probes are mounted on the circuit corresponding to water levels 1, 2 3 and

4. Any object that is able to conduct current can be used as a probe. The probe will work together with VCC probe. The VCC probe must be deployed deeply into the water. LED is used as the indicator that represents the water level. LED 1 represents level 1 and so on. Diode that is attached at the output of the IC used to block any feedback current. It can prevent any overload current from damaging the IC. This sensor will operate at 9 V operating voltage.

Water level sensor starts functioning when the water level reached probe 1 which is the first level and it will short circuit IC1 pin 1. The output from this IC which is pin 4 will turn on the first LED. If water didn't reach the first probe, the sensor will remain idle and microprocessor will read the sensor data as "0" or very stable condition.

The measuring process will continue and function appropriately according to the increment of the water. The LED will remain on as the water level increase to the next level which is level 2, 3 and 4. The critical situation will occur when all LEDs are turned on. It indicates that the water has reached the maximum level. Output from this sensor is connected directly to the microprocessor. Voltage measured at pin 4 and 10 of each IC are around 4.8 V and can effectively work with the microprocessor.

It is essential to take every precaution to avoid short circuit since water is also an electric conductor. This sensor must be placed far from the water source to avoid any short circuits.

3.2.2 Processor

The processing unit, which is commonly connected with a small storage unit, handles the procedures that make the sensor node work together with the other nodes to carry out the assigned sensing tasks. Processor can be defined as a single-ship device that contains memory for programmed information and data. It has logic programmed control reading inputs, manipulating data, and sending outputs. In other words, it has a built-in interface for input/output (I/O) as well as a central processing unit (CPU) [8]. The microcontroller unit is generally referred as MCU.

An 8 bit AVR RISC microcontroller is selected as the brain of water sensor system. The processor is selected based on its memory utilization. This processor has provides interesting features such as 8K bytes of in-system programmable flash with read while write capabilities, 512 bytes EEPROM, 512 bytes SRAM, 32 general purpose working registers, three flexible timer/counter with compare modes, internal and external interrupt, a serial programmable USART, a byte oriented two wire serial interface, an 8 channel 10 bit ADC, a programmable watchdog timer with internal oscillator, an SPI serial port and six software selectable power saving modes [5].

Figure 3.5 illustrate the Atmel Atmega8535 pin configuration. It shows all connection of I/O port, oscillator connection pin, USART transmit and receive pin and ADC port. This configuration must correctly follow the Atmel AVR datasheet to ensure the processor operate properly. This system utilizes almost the entire Atmega8535 pin out.

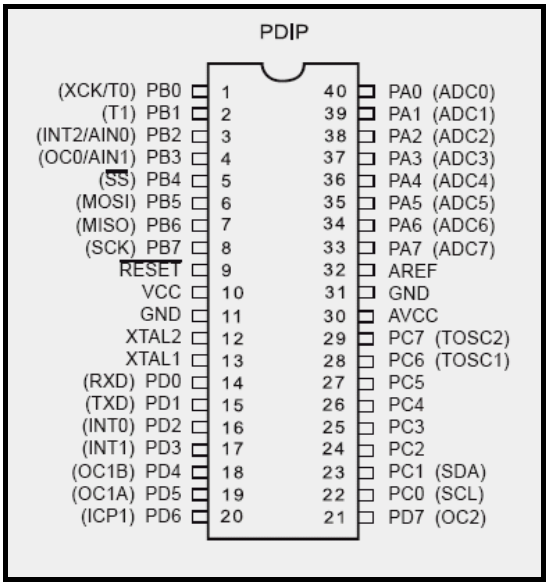


Figure 3.5 Atmega8535 pin configuration

As illustrated in figure 3.5, to enable the Microcontroller, it is essential to provide it with the suitable voltage. Referred to the datasheet, operating voltage for Atmega8535 is between ranges 4.5 V until 5.5 V. At this level, this microcontroller unit will function effectively. To obtain the optimum value of power source, a 5 Volt voltage regulator circuit was applied on the Microcontroller board. This circuit ensures that the Microcontroller received less than 5.5 Volt of supply during its operation. If more than 5.5 Volt of voltage is supplied directly to the board, the regulator decreased the value to avoid any damage to the microcontroller unit. Figure 3.6 shows the voltage regulator schematic diagram.

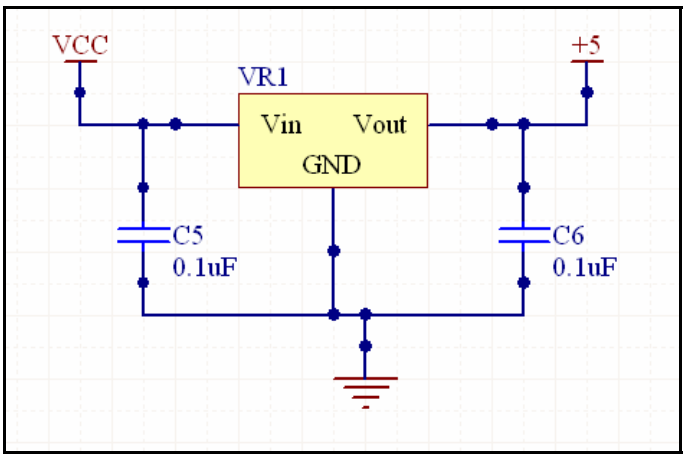


Figure 3.6 Voltage regulator schematic diagrams

ATmega8535 microcontroller uses an 8 MHz crystal oscillator to generate external clocking. Radio frequency transmitter was connected to pin 15 which are the USART pin, PORT B is applied for an ISP cable which is use to program the microcontroller directly on the circuit board, and PORT A was assigned as input port to read data from sensor.

Output gained from sensor was connected to PINA 1, PINA 2, PINA 3 and PINA 4. Each pin indicated different level of water which PINA1 is represent lowest water level while PINA 4 represent the highest or critical level. To ensure that PORTA can read the data captures by the sensor, the sensor itself must generate output voltage at 4.5 V – 5.5 V range.

Besides the register, the other pin that needed the special attention is pin 30 which is the AVCC. AVCC is the supply voltage pin for Port A and the A/D Converter. It should be externally connected to VCC, even if the ADC is not used. If the ADC is used, it should be connected to VCC through a low-pass filter [5]. To ensure the stability of the voltage supply, a 100 nF capacitor was connected to the VCC input. These capacitors should be placed as close to the power pins as possible.

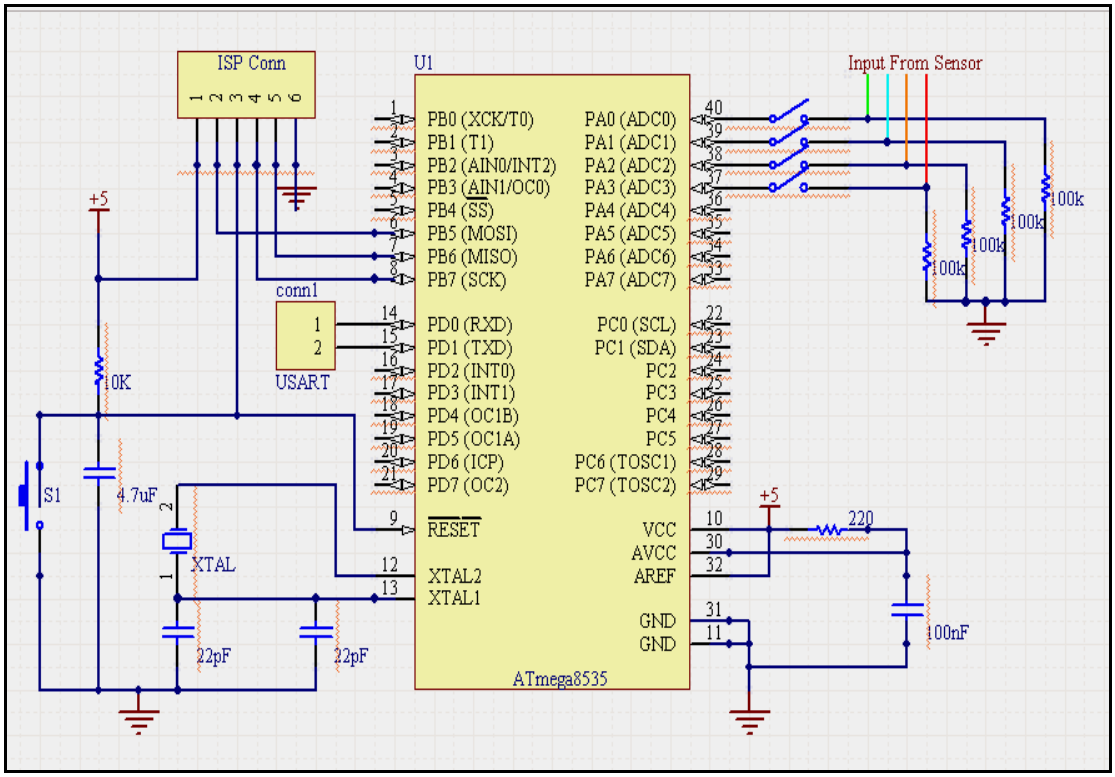


Figure 3.7 Microcontroller Board Schematic Diagram

Atmega8535 was manufactured using Atmel's high density non volatile memory technology. It allows the chip to be reprogrammed directly on the assembled microprocessor board using ISP cable. By combining an 8 bit RISC CPU with in system self programmable flash on a monolithic chip, the Atmel Atmega8535 is a powerful microcontroller that provides highly flexible and cost effective solution to many embedded control applications. Furthermore, Atmega8535 AVR is supported with a full suite of program and system development tools including C programming, macro assemblers, program debugger/simulators, in circuit emulators and evaluation kits. This microcontroller can be program using C programming, MikroBasic and its own assembly language. This program is then compiled to generate the Hex file. Finally this Hex file will be uploaded into the MCU.

3.2.3 RF Module

Radio Frequency modules are partially complete circuits that can be incorporated into larger designs. RF modules include receivers, transmitters and transceivers. RF modules employ numerous dissimilar modulation technique and radio system. The examples of modulation techniques use in RF module are on-off key (OOK), Amplitude modulation (AM), Frequency modulation (FM), Amplitude shift key (ASK), Frequency shift key (FSK) and Phase shift key (PSK).

Performance criteria for RF modules consist of sensitivity, output power, communication interface, operating frequency, and maximum transmission distance. Sensitivity described as a minimum input signal necessary to construct a specified output signal. Output power is the maximum signal power that RF modules can transmit. Operating frequency is the range of transmitted and received signals. Last but not least, maximum transmission distance is the maximum range that a transmitter and receiver can be separated.

A low cost stabilized surface mount RF transmitter RCT-433-AS from Radiotronix was chosen to be implemented in this system. This RF module includes a 433.92 MHz amplitude modulation version, 1.5-12V voltage operation, 5mA current consumption, small size, 0dBm output power and 4800 baud operation. The RCT-433-AS module is ideal for remote application where low cost and longer range are required. The 1.5 to 12 Volt operation voltages make it ideal for battery power applications. The transmitter utilizes a Surface Acoustic Wave (SAW) stabilized oscillator to ensure precise frequency control for best range performance.

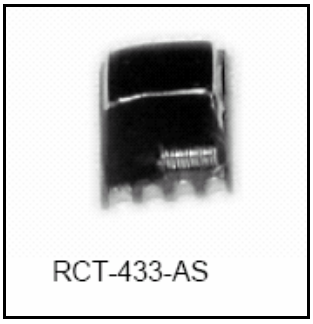


Figure 3.8 RF module

Figure 3.8 shows the RCT-433-AS transmitter module. The transmitter module pin description is described in table 3.1:

Table 3.1 RCT-433-AS pin descriptions

Pin No.	Pin Name	Description
1	ANT	50 ohm antenna output. The antenna port impedance affects output power and harmonic emissions. An L-C low-pass filter may be needed to sufficiently filter harmonic emissions.
2	GND	Transmitter ground. Connect to ground plane.
3	DATA	Digital data input. This input is CMOS compatible and should be driven with CMOS level inputs.
4	VCC	Pin 4 provides operating voltage for the transmitter. VCC should be bypassed with a .01uF ceramic capacitor and filtered with a 4.7uF tantalum capacitor. Noise on the power supply will degrade transmitter noise performance.

3.2.4 ISP Cable

One unique features offer by Atmega8535 is this chip can be program directly on the circuit board. Atmel offer a package call The Atmel AVR ISP which is In-System Programmer for Atmel's AVR Flash Microcontrollers. The AVR ISP gives the developer a compact and reliable programming tool to program all In-System Programmable AVR microcontrollers through a 6- or 10-pin ISP connector.

The AVR ISP uses AVR Studio, Atmel's Integrated Development Environment (IDE) for code writing and debugging. The programming software is user friendly and can be controlled from both a Windows environment and a DOS command-line interface.

Instead of using AVR ISP offer by the Atmel, developer also can build its own ISP cable. This ISP cable has the similar function with AVR ISP offered by Atmel. The ISP cable schematic diagram was illustrated in figure 3.9. This cable was cheap and effortless to build up. It can be the ideal starting for the developer.

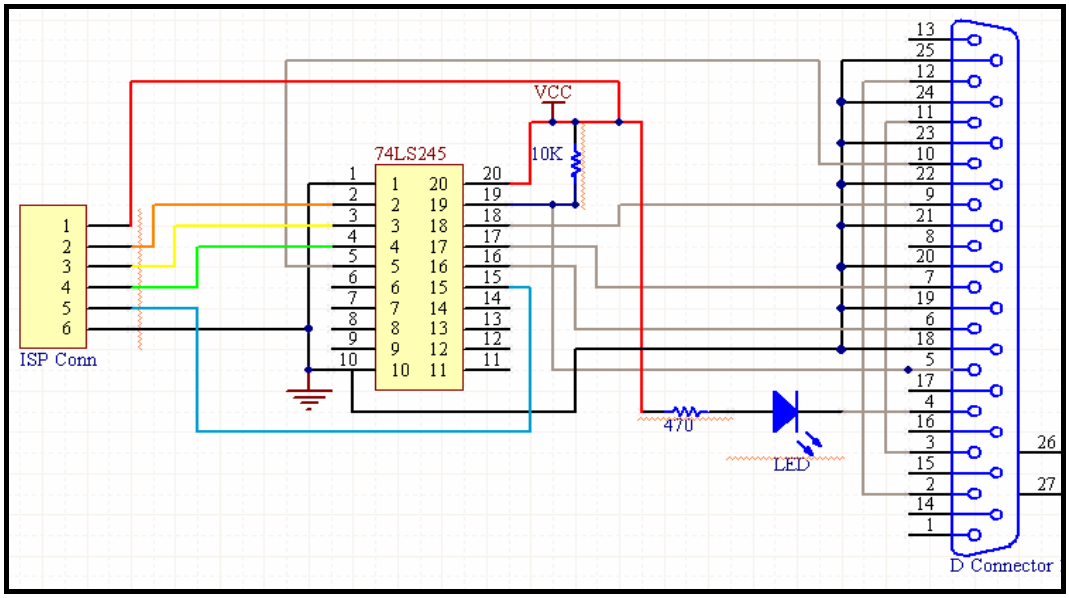


Figure 3.9 ISP cable Schematic Diagram

Components required in order to develop ISP cable are a DB25 connector, 74LS245 chip, 6 pin header, a 470 ohm resistor, a LED as a power indicator and jumper cables. There are 6 signals to be implemented in developing an ISP cable. It consist Master Out Slave in (MOSI) pin, Master in Slave out (MISO) pin, Shift Clock (SCK) pin and RESET pin. Another 2 pin are for VCC and ground. The function of ISP Connector pin is explained in table 3.2. The pin sequence followed the ISP conn pin header in the schematic.

Table 3.2 ISP connector pin descriptions

Pin No	**Name**	**Function**	**Description**
1	**VCC**	ISP Power	Power supply for the ISP. ISP header must supply power to the Dongle
2	**MOSI**	Master Out Slave In	Data being transmitted to the part being programmed is sent on this Pin
3	**RESET**	Target MCU Reset	Connect to target AVR. Target AVR is programmed while in Reset State
4	**SCK**	Shift Clock	Serial Clock generated by the Programmer
5	**MISO**	Master In Slave Out	Data received from the part being programmed is sent on this pin
6	**GND**	Ground	Common Ground

74LS245 was an octal tristate buffer. It used as the main component to the development of ISP cable. It was used to provide the float state after the hex code has been written into the AVR chip. The two loop-back connections, pin 2 to 12 and 3 and 11 is used to identify the ISP cable or so called as dongle. With both links in place the dongle is identified as a Value Added Pack Dongle. With only pins 2 and 12 links, it is reported as a STK300 or AVR ISP Dongle. With only 3 and 11, the dongle is reported as an STK200 or old Kanda ISP Dongle[1].

The LED implemented in this circuit was used as an indicator to detect the programmer. It is very useful during uploading the program into the microcontroller. The LED indicator will turn on when PC start up and it will blink when the code in written into the microcontroller. Otherwise, there might be an error arise during the programming.

3.3 Software development

Software development was the crucial part while developing this system. A lot of rework needs to be done when the result didn't achieve the initial target. In general, there are three major tasks need to be performed by sensor node which is read data from sensor, process the data to include data header, address, sensor data and frame check sequence and finally send the data to the receiver. As illustrated in figure 3.10, the work flow began by building the application flowchart. This flowchart was a necessary guideline to be follow during accomplishing the system. Next step is writing a program according to the application. The program was written in C programming. After that, a make file was set up. Make file was essential because it can determines the types of linker, loader and the object files to be produced.

After completing the program, it needs to be compiled. The written program was compiled using WinAVR. WinAVR ensure that the codes generated from the program are compatible with Atmega8535. This point demands a lot of rework if any errors are detected during compiling. The system need to be altered and reprogram to resolve the error. Once the programs are free from error, WinAVR compiler will generate a Hex file. This is a very useful file that required to be uploaded into the microcontroller unit.

After the Hex file were uploaded into the microcontroller unit, the whole circuit can be tested either it compatible or function accordingly to the application. Rework also necessitate if the expected result couldn't be obtained.

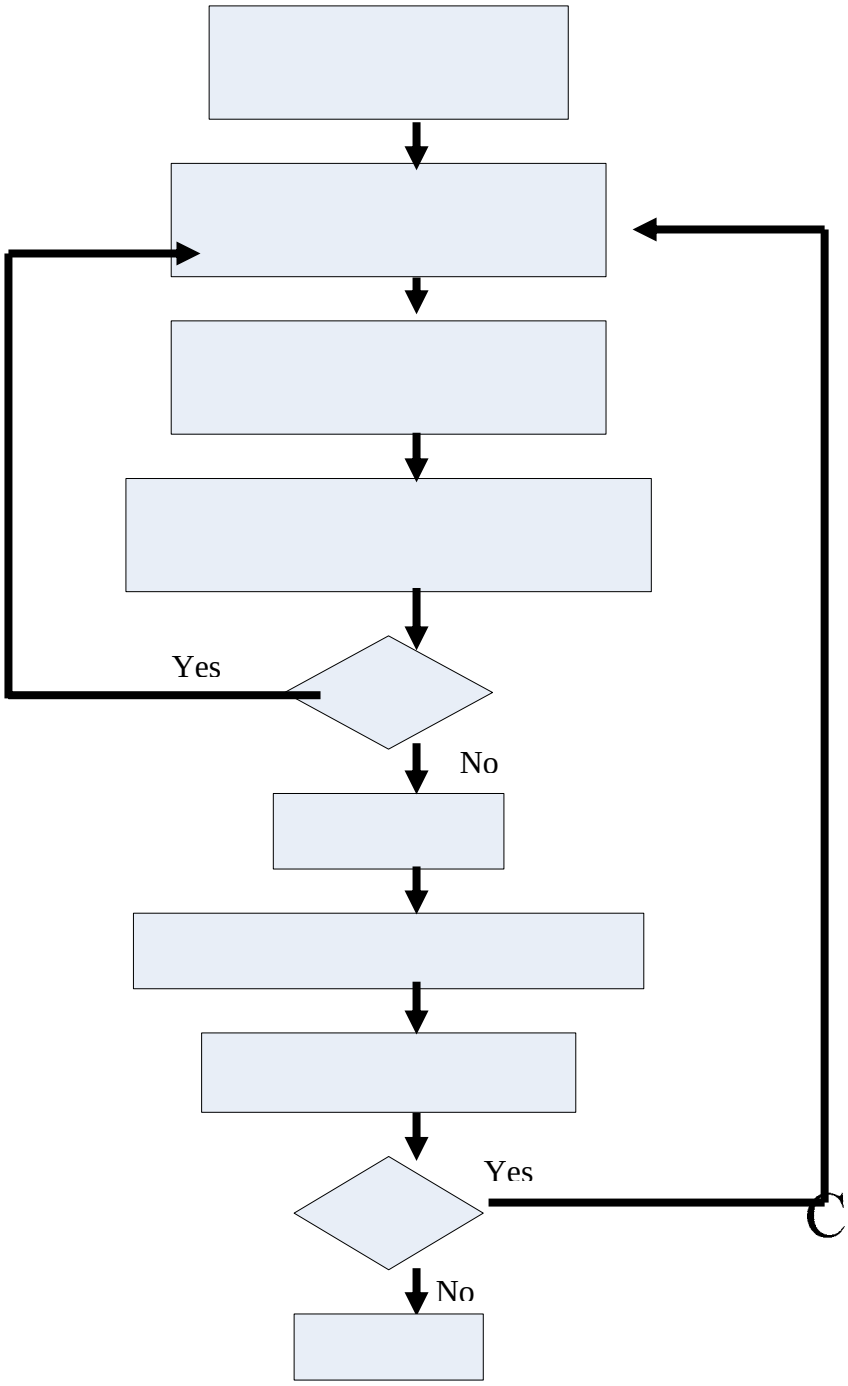


Figure 3.10 Software development flow chart

Figure 3.11 shows the flowchart that describes the program written to read the sensor input. The program began by port configuration. PORT A at the microcontroller unit was assign as input port. Nest step was reading the input port, and then the data was compared to obtain the actual level of water. Finally the data was store and used for the whole program.

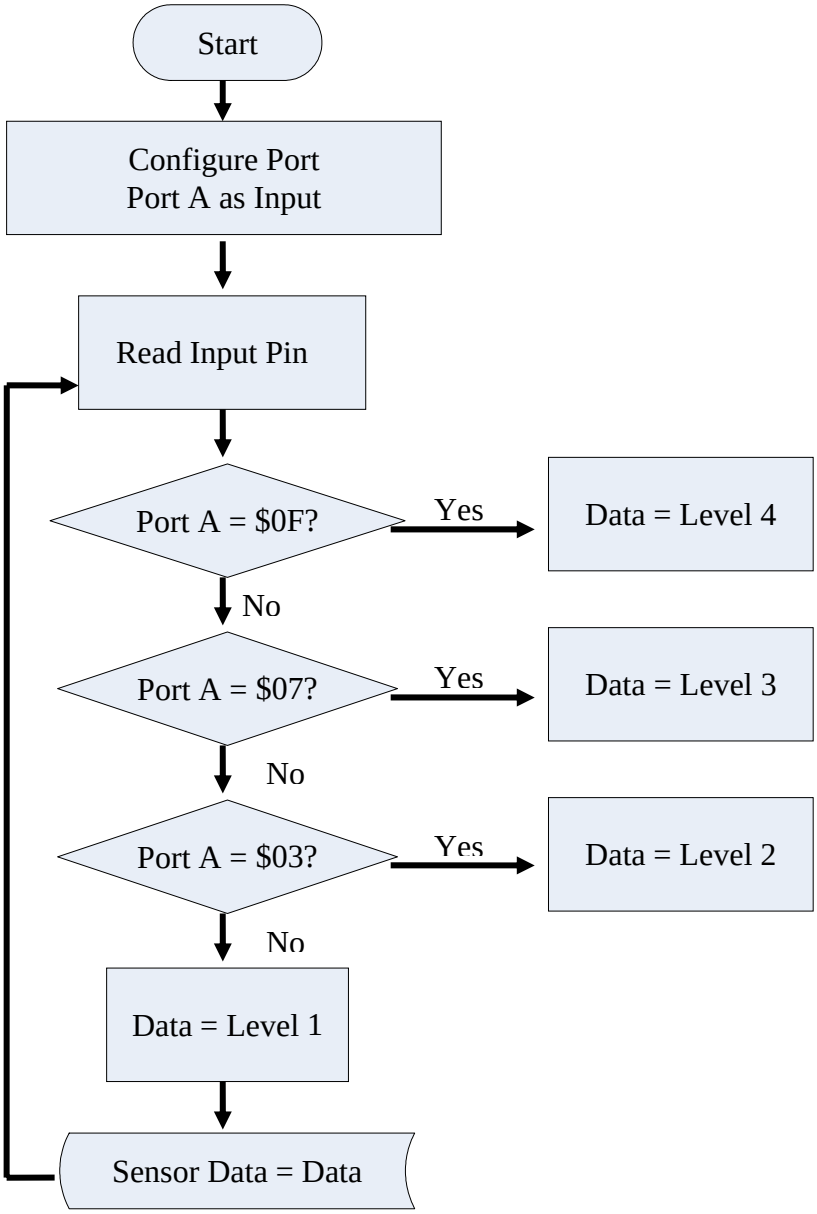


Figure 3.11 Sensor flowchart

Based on figure 3.13, the program start by initialized the microcontroller Port. In this system Port A from the microcontroller was used as the input port. The steps followed by initialized the USART function. Those USART initializing codes can be referring in the ATmega8535 Datasheet. Water sensor system employs a serial communication to transfer between two microcontrollers. The next step was read the sensor data. Data read from sensor the stored as sensor data. Next was inserted header which use as frame synchronization, followed by address as the indicator receiver port name into the frame. Then sensor data was inserted into the

frame, followed by checksum. Checksum is an error- detecting code based on a summation operation performed on the bits to be check. The formula to generate Checksum Code is:

Checksum = - (Header1 + Header2 +Address1 + Address2 + Data)

The sensor data then send through the network in a form of frame as shown in figure 3.12

Header (2 Bytes)	Address (2 Bytes)	Sensor Data (1 Bytes)	Checksum (1 Bytes)

3.12 Sensor data frame format

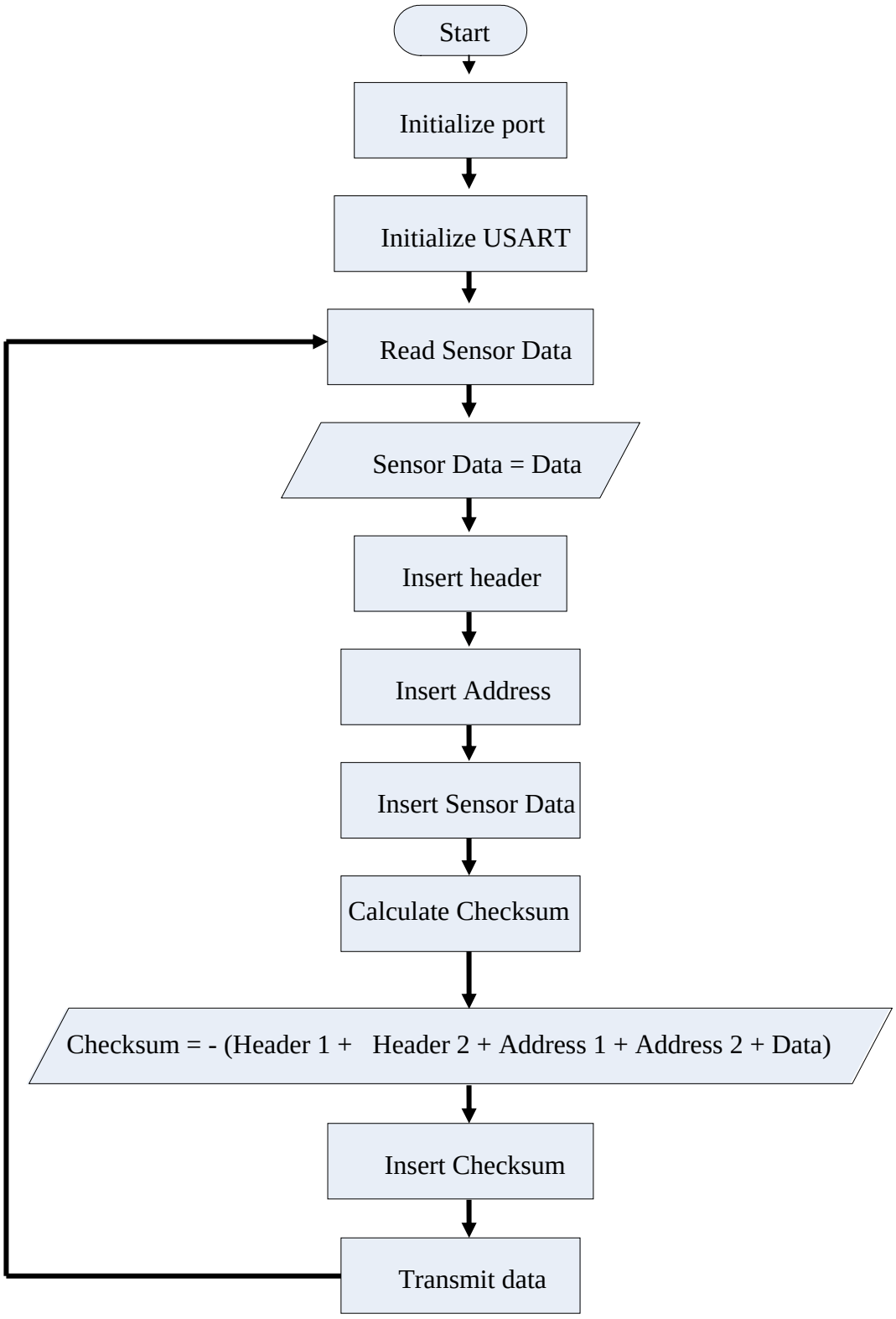


Figure 3.13 Data Transmission flow chart

3.3.1 Code development

Several software was involved to accomplish this project. The source code was written in C language. The code written need to be complied to generated the Hex file and finally the Hex file was uploaded into the microcontroller unit. The choice of software used are depends on the most convenient way to implement the code generated into the microcontroller unit. Two major software that mostly used during completing this system are WinAVR and PonyProg.

3.3.1.1 WinAVR

The initial step was writing the source code in C programming language. For this purpose, the code can be written in Visual C, notepad or WinAVR programmer notepad. On the other hand, for compiling purpose, a WinAVR code compiler was used to compile the written program and generated the Hex file. This software was choose since it offer a complete development tools including the programmer notepad, compiler, Assembler, linker, AVR library , file converter, debugger and so on. WinAVR compiler was complete software while developing this project. It is flexible and can be hosted on many platforms. Furthermore, WinAVR can target many different processor and extremely compatible for most Atmel's ICs.

There are a few steps to be followed while writing a program using this software. First step was writing the source codes and save it in a specified folder. Then save the file created according to the source codes language. For example *.asm*, .c, etc. In this case the file must be saved as *filename.c.*

After that, the next step was edited the makefile according to the target device. Makefile is a text file that that lists and controls the program and the microcontroller unit. Three changes need to be done. First, change the PRG and OBJ to the name of the source code and lastly edit MCU_TARGET depends on what type of microcontroller used. If these steps were missing, an error may occur because the

program didn't recognize the registers use in the program. Afterwards, the makefile was saved in the same folder for source code file.

In order to clean any existing file except for the code and makefile, make clean command was choose in the tools panel. Finally, choose make all command in the tools panel to make all file for the program such as *filename.lst, filename.obj and filename.hex*. Those three file is the code used and will be uploaded into the microcontroller. Figure 3.14 show the programmer notepad of WinAVR window environment. The main program is shown at the back window and the upper windows illustrate the makefile setup for the system main program.

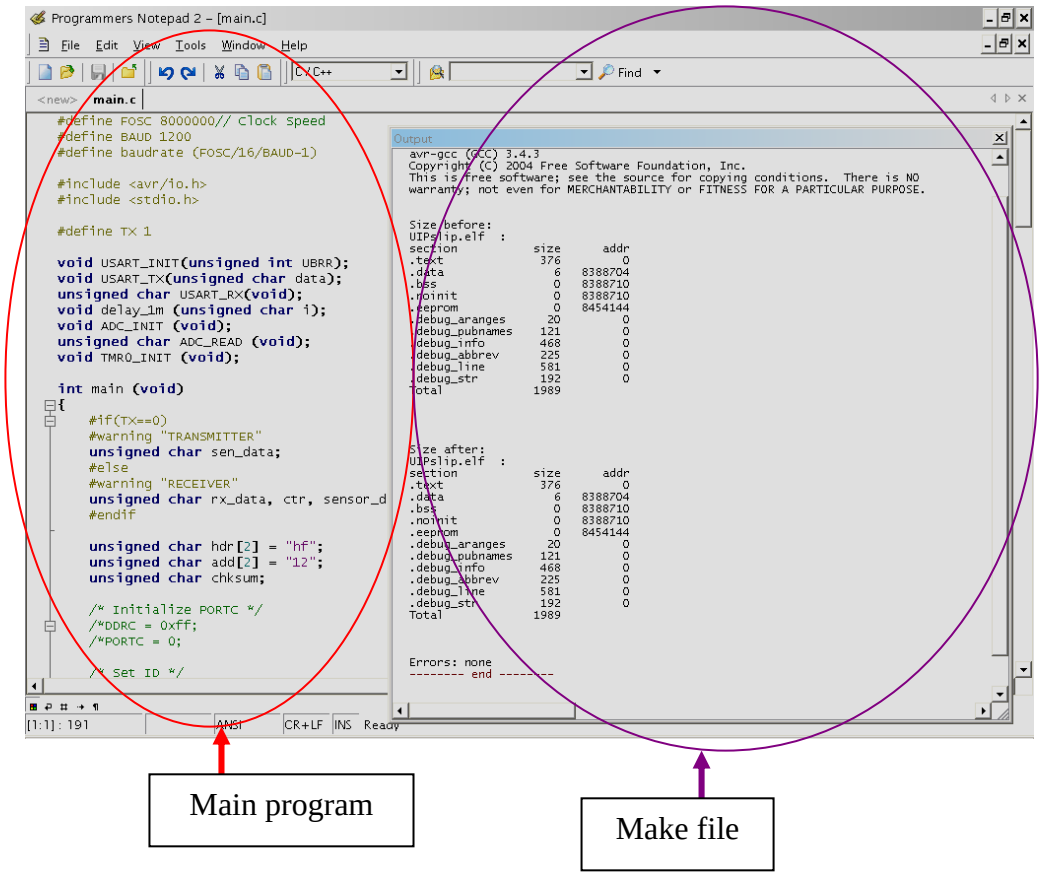


Figure 3.14 WinAVR notepad and makefile window

3.3.1.2 PonyProg

The next step after generating the Hex file is uploading the generated Hex file into the microcontroller. To uploading the Hex file, the other software was used which called PonyProg. PonyProg is serial device programmer software with a user friendly GUI framework available for Windows95, 98, 2000 & NT and Intel Linux. Its purpose is reading and writing every serial device. PonyProg works with other simple hardware interfaces like AVR ISP (STK200/300), JDM/Ludipipo, EasyI2C and DT-006 AVR (by Dontronics) [3]. The PonyProg window shown in figure 3.15.

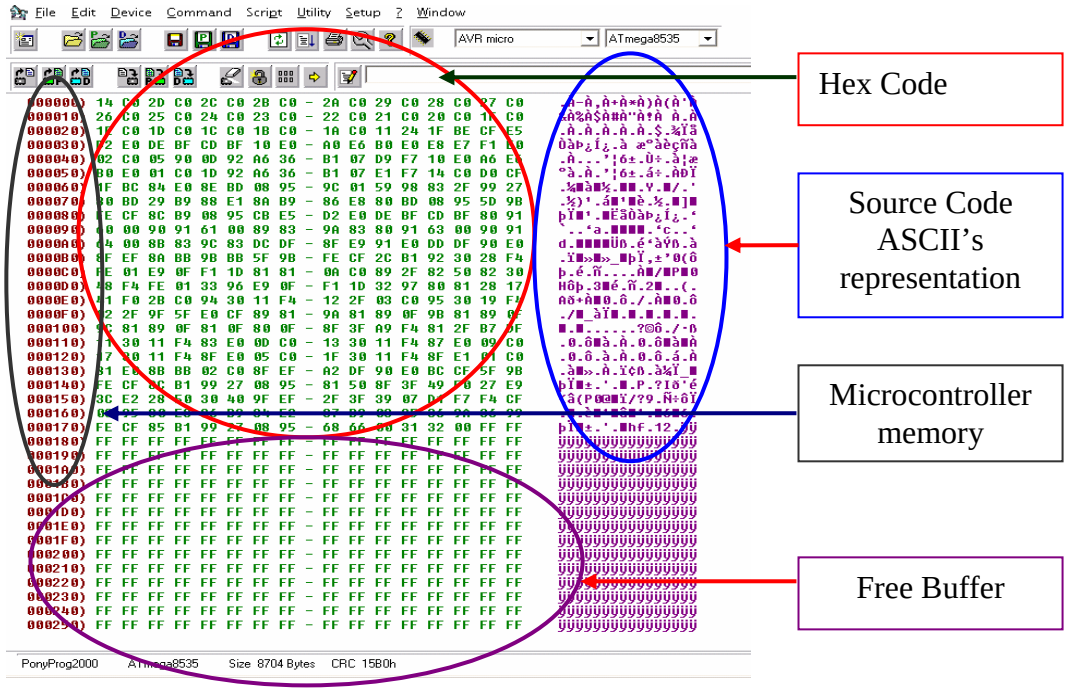


Figure 3.15 PonyProg window

The figure 3.15 shows the hex file generated after compiling the source code in WinAVR. The Ponyprog window contains the Hex code compiled from the original program written in C language, the source code ASCII's representation, microcontroller memory and the unused microcontroller buffer. The essential steps require before using this software was first, setup the interface whether to use serial or parallel connector. Secondly, calibrate the bus timing, define the device going to be used and setup the configuration and security bits. One completing the calibration and setting, the selected hex file can be downloaded into the microcontroller unit. It is essential to ensure that right memory location has been chosen for the programming either in flash or EEPROM memory. The full Ponyprog setup enclosed in appendix D

CHAPTER 4

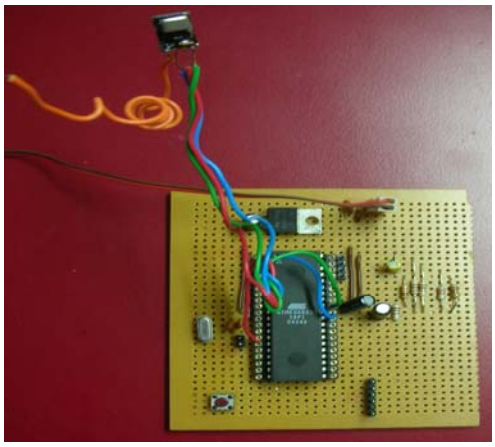
RESULTS AND ANALYSIS

Overall, this chapter discussed the result attained from the system development and analysis for each result. The result was obtained from both wired and wireless communication. Result obtained from these system output measured using oscilloscope and the data transmitted can be read using USART terminal. Some of the result was captured using ISIS Proteus software. Wave captured from this software was similar with the data captured by the oscilloscope. To obtain the result, this software read the data from RS232 connector that connected from the microcontroller board to the computer. The results have been analyzed to guarantee data collected at the receiver node is similar as transmitted at the transmitting node.

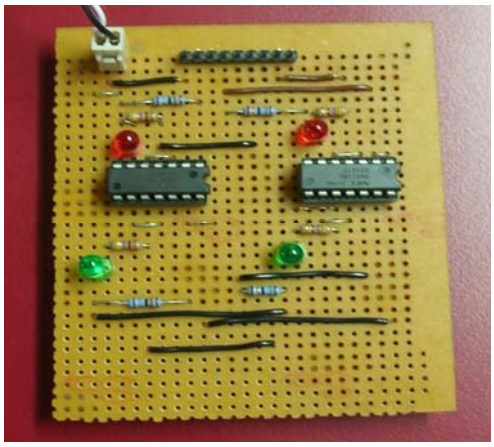
4.1 Hardware Development

As mentioned in chapter 3, water sensor system design process divided onto three phases which are the electronic design or the hardware development, sensor node programming or the software development and final phase, the overall system testing development. This system successfully completed the first phase of the system development which is the development of electronics components.

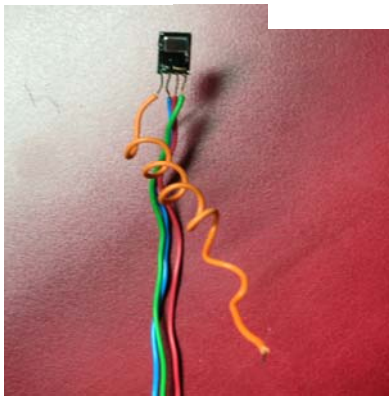
Figure 4.1 shows the completed processor board connected with the transmitter module. Figure 4.2 shows the sensor built up to measure the water level. Next figure 4.3 shows the RF transmitter module used to convey data wirelessly from the transmitter node to the receiver node.



Processor board



Sensor Board



RF Transmitter modules

Figure 4.4 shows a complete system developed for water sensor system on the transmitter node. The prototype includes the processor board, sensor board transmitter module and a water level modeler. The sensor and processor board was powered by 9 Volt Lithium batteries. At the processor board, 9 volt lithium batteries connected to the voltage regulator to keep the supply lower than 5 Volt according to the microcontroller operating voltage. The RF module use the same supply on the processor board since its operating voltage may vary from 1.5 V to 12 V.

Figure 4.5 show the ISP cable which is In-System Programmer for Atmel's AVR Flash Microcontrollers. ISP simplified the code uploading process. By using this cable, developer may program the generated code directly on the circuit board. Unlike the ordinary boot loader, by using ISP cable, developer doesn't have to plug out the microcontroller unit in order to load the hex file.

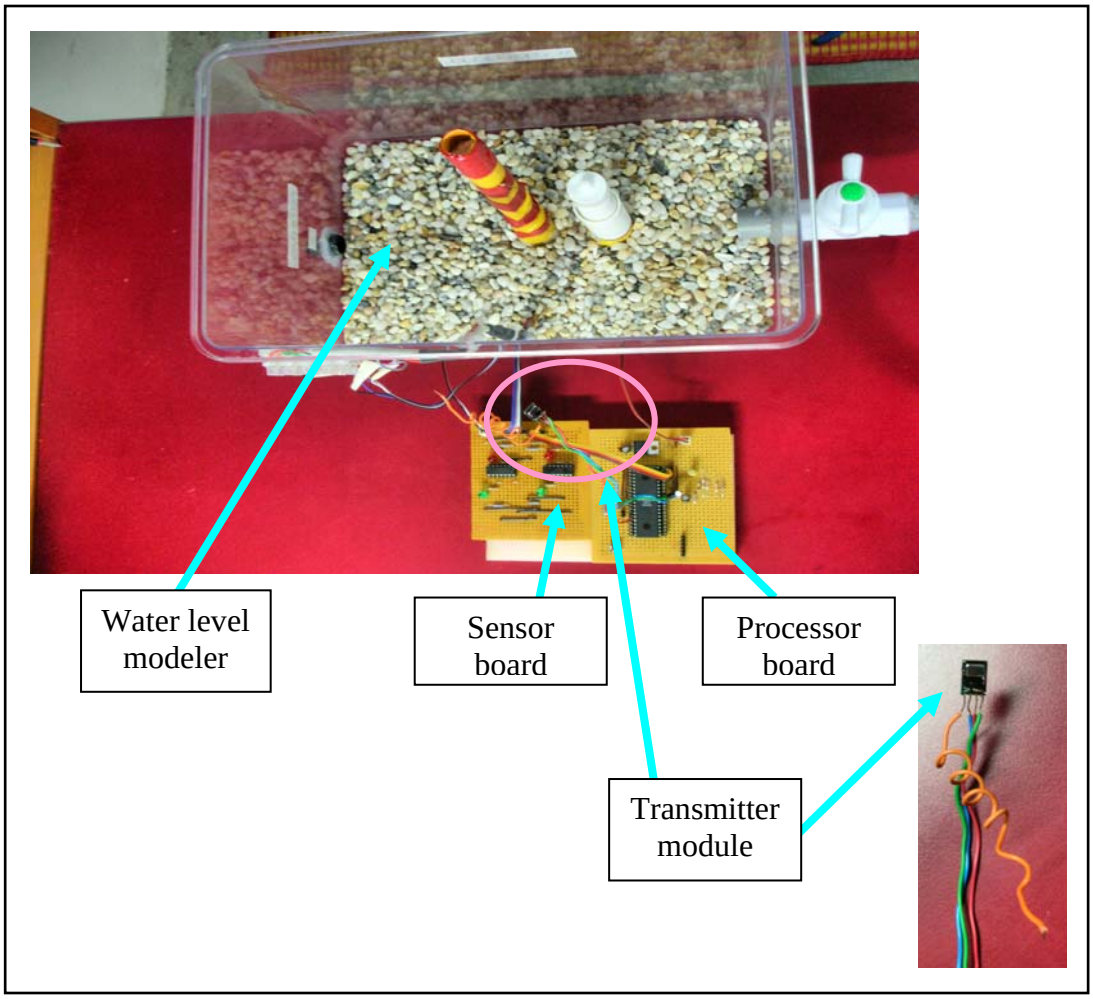


Figure 4.4 Water Sensor System Prototypes

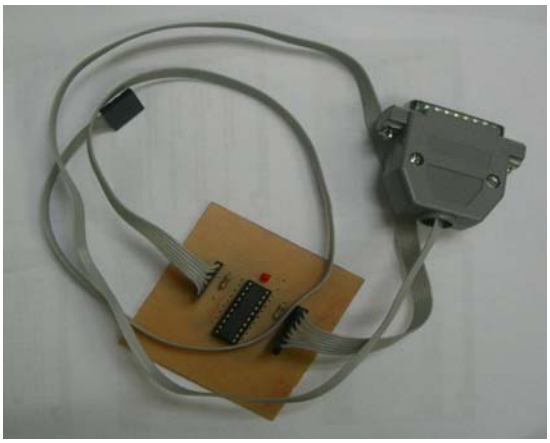


Figure 4.5 ISP Cable

4.2 Software Development

The next phase of water sensor system development was built up the software and writes a program in C language in the WinAVR programmer notepad. Afterward the source codes will be compiled using WinAVR compiler. Figure 4.6 proved this phase was completed. The back windows shows the C programming language for the system and the front window shows the output from the compiler. The compiler will create certain files such as <filename>.eep, <filename>.o, <filename>.obj, <filename> .lst and <filename> .hex. Apart of that, if any error generated, the execution will stop and it error message will display in the output window.

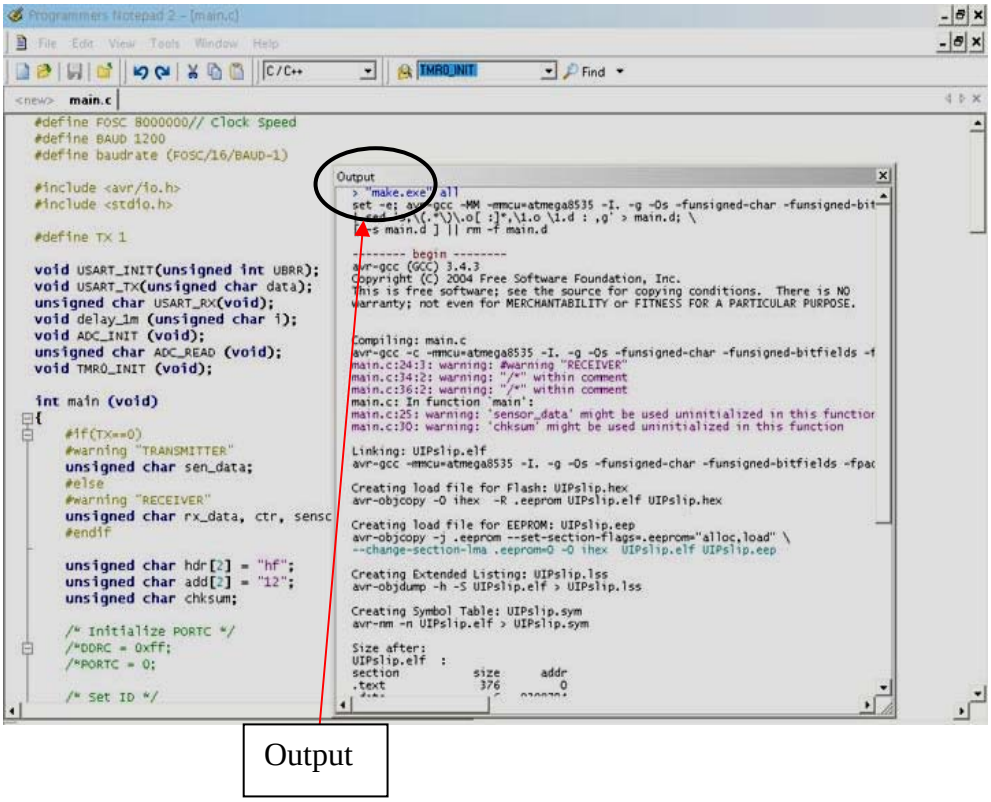


Figure 4.6 C Language program in WinAVR Programmer Notepad

4.3 Measured Voltage

Figure 4.7 shows the voltage supply connected to microcontroller VCC input pin. The purpose of measuring the supply voltage is to ensure that the microcontroller was supplied with a stable voltage. This voltage is the similar output voltage from voltage regulator circuit. The oscilloscope was set to 2V/div therefore from the reading, the signal vary into 2 ½ box which is 2.5x2=5 volt.

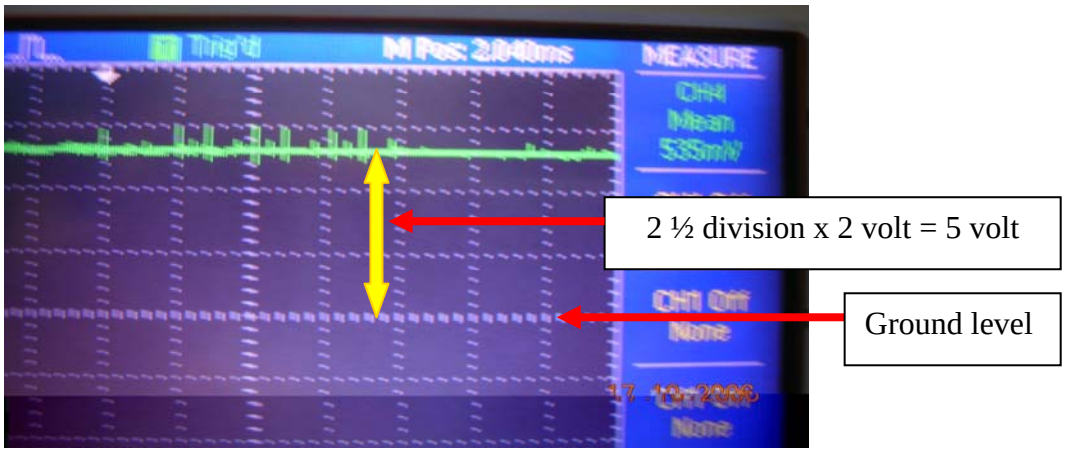


Figure 4.7 Measured input voltage for processor board

4.4 Sensor data transmission

Figure 4.8 show the changes of sensor data. It shows that the water level changes from level 0 until level 2. The result was captured using hyperterminal during the transmission of sensor data using wireless module. The data captured using ASCII format because the transmitter node was programmed to send the ASCII value as the level indicator.

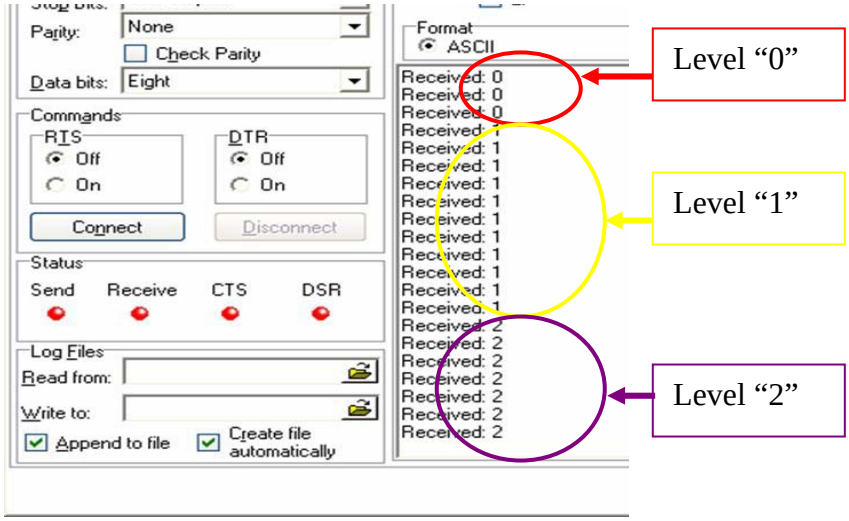


Figure 4.8 Sensor data transmission (hyperteminal)

Figure 4.9 show the sensor reading during level 2nd level of water was detected. The reading captured at the Usart Transmitter pin and read on the ISIS Proteus software. The oscilloscope reading shows the wave generated in this transmission. ASCII “2” represents Hex value “32” which is equal to “0011 0010” in binary number. The start bit for the transmission is “0” while the stop bit is “1”.

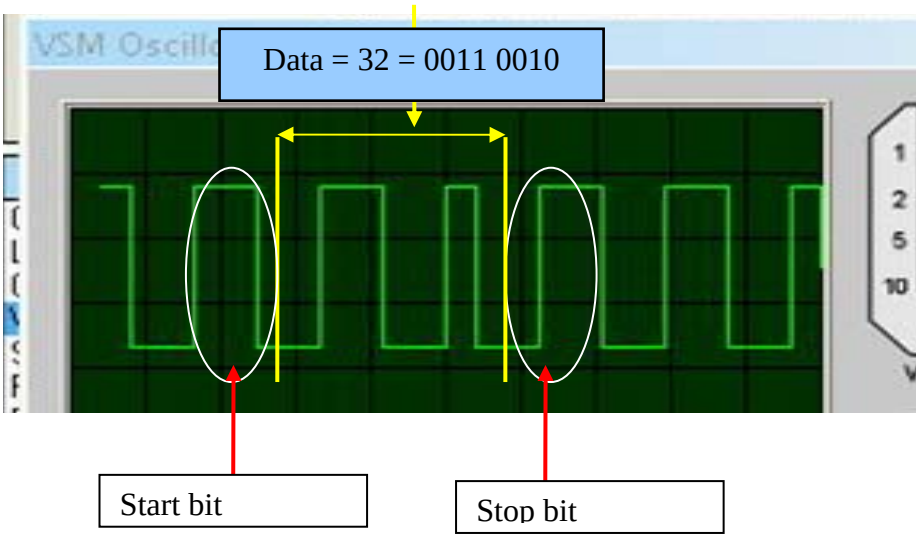


Figure 4.9Sensor data transmission (oscilloscope)

4.5 Data Transmission between Sensor Nodes

Data transmission between sensor nodes explains the result obtained during wired and wireless transmission.

4.5.1 Wired transmission

Figure 4.10 and 4.11 explain the observed data during wired transmission. Figure 4.10 shows the data captured at the virtual terminal. The data sent through the network including 2 bytes header, 2 bytes address, 1 byte data and 1 byte checksum as discussed in chapter 2. The red circle show the data frame received the receiver node while the green circle explains the extracted data from the receiver node that will be sent to computer for GUI display.

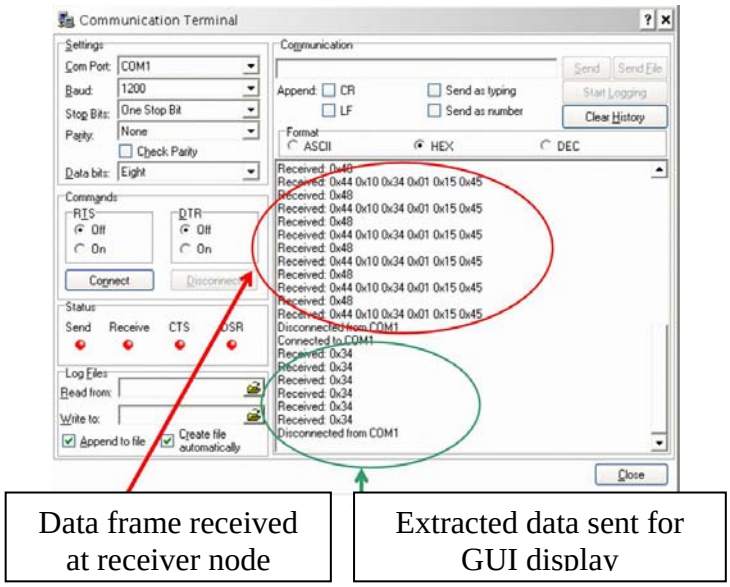


Figure 4.10 Communication terminals for wired data

Figure 4.11 shows the wave generated during data transmission. This data were collected at transmitter node's USART transmit pin, receiver node's USART receive pin and receiver node's USART transmit pin. The result consists of a start bit, a stop bit and the original data as defined in the frame format. The bits were defined out serially starting with the start bit of '0', followed by the MSB and end with stop bit of '1'. The bits shifting operation was analyzed according to Big Endian Byte order. As shows in the figure, the same bit sequence that being transmitted from the transmitter was observed at the receiver node. Apart of that, there are some delays when sending the data from receiver node to the computer. This scenario happen because data from transmitter must be extracted by the receiver before sending it back to the computer. So the process only possible after the whole frame was received.

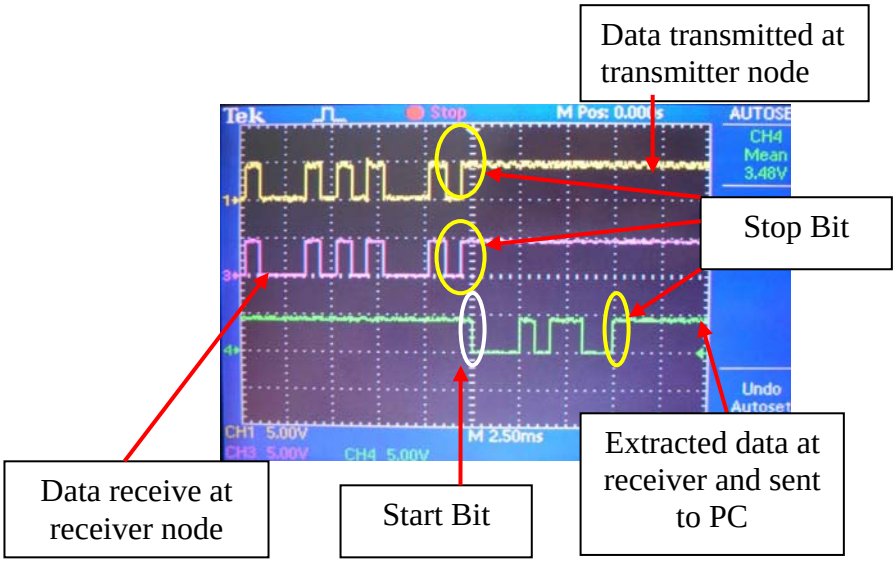

Data transmitted at transmitter node
Stop Bit
Extracted data at receiver and sent to PC
Start Bit
Data receive at receiver node

Figure 4.11 Observed data during wired transmission

4.5.2 Wireless transmission

Figure 4.12 shows data transmitted using wireless communication. As shown in the figure, at the bottom of the oscilloscope shows that all channels have the similar voltage value. The transmitter module can operate with the same level with the receiver module which is 5 volt. So no signal distortions occur during the transmission. It can be proves at channel 1 and channel 2 voltage reading at the bottom of oscilloscope display. Channel 3 represents the signal sent from receiver node's USART transmitter. This signal didn't experience any critical issue since the data from this pin was transmitted to computer using wired transmission.

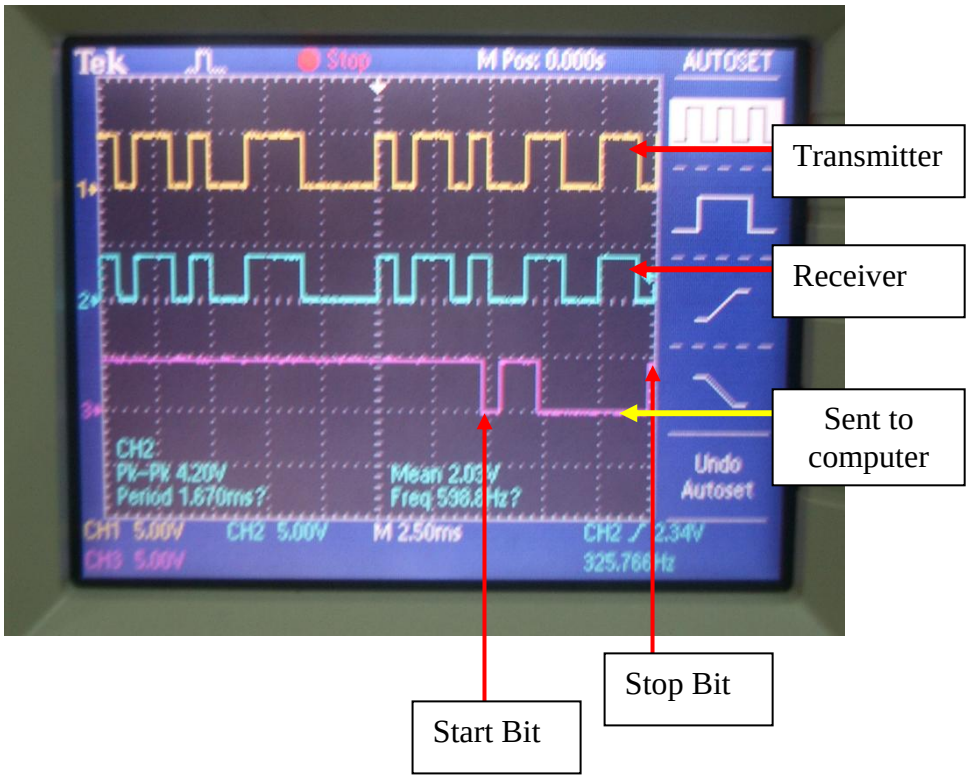


Figure 4.12 Observed data during wireless transmission

As the illustrated, the result both transmitter ad receiver nodes had been determined. Data may only capture by receiver node when the connection has been establish. Same socket address must be used to obtain the result; otherwise, data transmitted from the transmitter node cannot be received at the receiver side.

4.6 Graphical User Interface

Graphical user interface was developed as the additional indicator of the water sensor system. The GUI displays the current water level sense by the sensor node and transmitted to the receiver node. As shown in figure 4.13, the GUI display shows that on Wednesday, November 1st, 2006 at 1:09:02 PM the water indicate that the water level was at the range of 2 meter. The level described as average and indicates by the yellow label. This colour indicator will change accordingly to the increments of the water level. The changes of water level indicator were enclosed in appendix C.

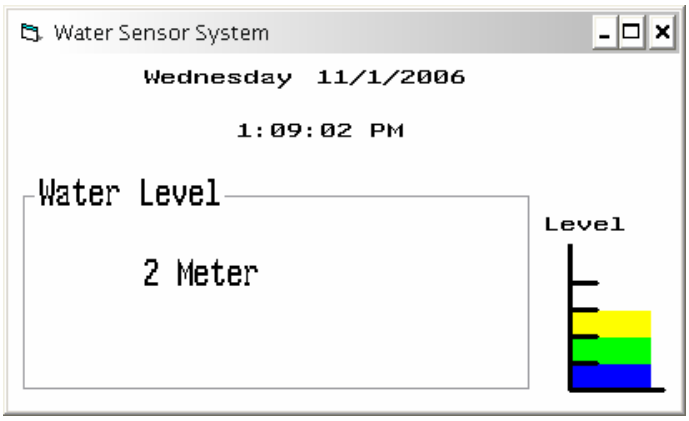


Figure 4.13 GUI water level indicators.

CHAPTER 5

CONCLUSION AND SUGGESTION

5.1 Conclusion.

By the end of the day, this water sensor system has successfully achieved its main objective. The system was successfully created with the ability to do sensing, processing and communicate between the nodes. This system completes the main task which is to sense the existence of water and measure several point of water before it burst the maximum level and transmit the collected data to the receiver node for further action. Furthermore, this water sensor system is able to perform its operation in a real time operation with a tiny delay.

In some way, by implement this water sensor system might be helping resident within the flood area to get prepare before the flood happen. By implementing this system, it can as well as reducing the resident loss due to flood. The best way to implement this system is putting the sensor at the police station or neighborhoods center. The person who is on duty that day will inform if any danger encounters the resident area and ask them to prepare, pack their goods and move to safety places. Besides contribute as the flood alarm, this system also offers the other benefit where it can be use to measure water level in the dam. It might help certain area that facing the water supply problem.

5.2 Discussion and Future Work.

Implementation of TCP/IP protocol in a wireless sensor network was said to be a hard task due to limitation of memory in the microcontroller. In a very limited memory sizes, wireless sensor network developer should employ the gathered sensor data as well as the protocol data into the microcontroller and finally sending the processed data to the receiver. The processed data that sent through the network including data header, IP address, sensor data and checksum. Different from computer communications, sensor network didn't have specific server to allocate and generate its own IP address. In wireless sensor network, the developer should assign its own IP address for each sensor or nodes depending on the network size. The wireless sensor networks form a temporary network without any deployed infrastructure or centralized organization. Each node that communicates each other has an independent algorithm.

The deployment of wireless sensor network also said to be critically in term of power efficiency. A node in wireless sensor network is not only performing as a host, but in order to communicate each other in the network, a node also performs as a router. Due to these reason, the node has conflicting of saving energy for its own transmission and relaying the data to other node so the network wont break or fall apart. This will be a challenge in deployment a large scale wireless sensor network.

This project may be enhancing by implementing a smaller size sensor compare to the one that have been develop in this project. A smaller sensor will suit the criteria of a wireless sensor network which is developing a tiny node that equivalent to the coin size. Other than that, a study about power consumption should be perform so that the nodes might work in a longer time and an effective data may be delivered thus distortion can be avoided.

Furthermore, a sensor node should apply more than one sensor so that the real sensor network can be performing with a complete protocol. Beside that, the development of multi-hop wireless sensor network also recommended for future work so that the many sensor node can interact each other.

Moreover, a complete protocol should be implementing in the wireless sensor network to ensure the reliability and security of data. The data sent over the network shouldn't be lost or damage. If this happen if may effect the entire network and the actually sensing data is not possible to obtain. Moreover, a central node should be developing to gather all data from its network. This central may collect the data from its network and store the data into a database to keep record for further reference if anything happen in the environment.

In order to develop the entire sensor network, it requires the developer to use a transceiver instead of using a stand alone radio frequency transmitter or receiver. Transceiver will possible any two way communications and protocol to be embed in the sensor network. PPP protocol can possibly be employed into the network so that the security and reliability of data are certainly sure. Other than that, transceiver enables both nodes to communicate each other, sending acknowledgement to ensure data transmission and if necessary the node can resent any damage data

Finally a research on traffic delay, routing protocol and energy saving also should be done to establish the development of wireless sensor network. The research will enhance the wireless sensor network performance in term of traffic delay, longer operation time for each and effective bandwidth. Other than that, the optimal number of nodes and path can be obtaining to ensure the entire network work efficiently.

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APPENDIX A
TRANSMITTER NODE SOURCE CODES
TRANSMITTER NODE MAKE FILE

```
#define FOSC 8000000// Clock Speed
#define BAUD 1200
#define baudrate (FOSC/16/BAUD-1)

#include <avr/io.h>
#include <stdio.h>

#define TX 1

void USART_INIT(unsigned int UBRR);
void USART_TX(unsigned char data);
unsigned char USART_RX(void);
void delay_1m (unsigned char i);
void ADC_INIT (void);
unsigned char ADC_READ (void);
void TMR0_INIT (void);

int main (void)
{
      #if(TX==0)
      #warning "TRANSMITTER"
      unsigned char sen_data;
      #else
      #warning "RECEIVER"
      unsigned char rx_data, ctr, sensor_data, chksum_;
      #endif

      unsigned char hdr[2] = "hf";
      unsigned char add[2] = "12";
      unsigned char chksum;

      /* Initialize PORTC */
      /*DDRC = 0xff;
      /*PORTC = 0;

      /* Set ID */

      /* Initialize Timer0 & USART */
      TMR0_INIT();
      USART_INIT(baudrate);

      #if(TX==0)
      /* Initialize ADC */
      DDRA = 0xF0;

    while (1) {
            sen_data = PINA;
            chksum = sen_data + hdr[0] + hdr[1] + add[0] + add[1];
            chksum = ~chksum;

            USART_TX(hdr[0]);
            USART_TX(hdr[1]);
            USART_TX(add[0]);
            USART_TX(add[1]);
            USART_TX(sen_data);
            USART_TX(chksum);
      }

      #else
      ctr = 0;
```

```
	DDRA = 0xff;
	PORTA = 0;

	while (1) {
		if (UCSRA & (1<<RXC)) {
			rx_data = UDR;

			if (ctr < 2) {
				if (rx_data == hdr[ctr]) {
				    ctr++;
				} else {
					ctr = 0;
				}
			} else if ((ctr > 1) && (ctr < 4)) {
				if (rx_data == add[ctr - 2]) {
					ctr++;
				} else {
					ctr = 0;
				}
			} else if (ctr == 4) {
			    sensor_data = rx_data;
				ctr++;
			} else if (ctr == 5) {
				chksum = rx_data;
				ctr++;
			} else {
				chksum_ =  (hdr[0] + hdr[1] + add[0] +
add[1] + sensor_data + chksum);
				if (chksum_ == 0xff) {
					USART_TX(sensor_data);

					if (sensor_data == 0x1) {
						PORTA = 0x3;
					} else if (sensor_data == 0x3) {
						PORTA = 0x7;
					} else if (sensor_data == 0x7) {
						PORTA = 0xf;
					} else if (sensor_data == 0xf) {
						PORTA = 0x1f;
					} else {
						PORTA = 0x1;
					}
				} else {
					USART_TX(0xff);
				}
				ctr = 0;
			}
		}
		//if (TIFR & 0x2) {
		//    TIFR |= 0x2;
		//    TCNT1 = 34328;

		//    PORTA = 0xf0;
		//    while (1);
		//}
	}

	/*    if (TIFR & 0x1) {
			TIFR |= 0x1;
			TCNT0 = 226;
```

```
                PORTC = ~PORTC;
            }*/

      #endif
}

void USART_INIT(unsigned int UBRR)
{

/* Set baud rate */
UCSRA &= 0xfd;
UBRRH = (unsigned char)((UBRR)>>8);
UBRRL = (unsigned char)(UBRR);

/* Enable receiver and transmitter */
UCSRB = (1<<RXEN)|(1<<TXEN);

/* Set frame format: 8data, no parity, 1 stop bit */
UCSRC = (1<< URSEL) | (1<< UCSZ1) |  (1<< UCSZ0);
}

void USART_TX(unsigned char data)
{
   /* Wait for empty transmit buffer */
   while ( !(UCSRA & (1<<UDRE)) ) ;

   /* Start transmission */
   UDR = data;  // send least significant byte
}

unsigned char USART_RX(void) {
   /* Wait for data to be received */
   while (!(UCSRA & (1<<RXC))) ;

   /* Get and return received data from buffer */
   return UDR;
}

void delay_1m (unsigned char i)
{
    int j;
      while(i--)
      {
            j=11415;   // 8Mhz Exteranl Crystal(CKSEL3..0 = 1,1,1,1)
            while(j--);
      }
}

void ADC_INIT (void)
{
    // Activate ADC with Prescaler 2
      ADCSRA = 0b10000000 ;
      ADMUX = 0b00100100;
}

unsigned char ADC_READ (void)
{
      ADCSRA |= 0B01000000;
      while (ADCSRA & _BV(ADSC) ) {}

      return ADCH;
```

```
}

void TMR0_INIT (void)
{
      //TCCR0 = 0x05;
      TCCR1A = 0;
      TCCR1B = 0x4;
}
```

Transmitter Node Makefile

```
# MCU name
MCU = atmega8535

# Output format. (can be srec, ihex, binary)
FORMAT = ihex

# Target file name (without extension).
TARGET = wlevel

# Optimization level, can be [0, 1, 2, 3, s]. 0 turns off
optimization.
# (Note: 3 is not always the best optimization level. See avr-libc
FAQ.)
OPT = s


# List C source files here. (C dependencies are automatically
generated.)

# If there is more than one source file, append them above, or
modify and
# uncomment the following:
#SRC += foo.c bar.c

# You can also wrap lines by appending a backslash to the end of the
line:
#SRC += baz.c \
#xyzzy.c



# List Assembler source files here.
# Make them always end in a capital .S.  Files ending in a lowercase
.s
# will not be considered source files but generated files (assembler
# output from the compiler), and will be deleted upon "make clean"!
# Even though the DOS/Win* filesystem matches both .s and .S the
same,
# it will preserve the spelling of the filenames, and gcc itself
does
# care about how the name is spelled on its command-line.
ASRC =


# List any extra directories to look for include files here.
#     Each directory must be seperated by a space.
EXTRAINCDIRS =


# Optional compiler flags.
#  -g:        generate debugging information (for GDB, or for COFF
conversion)
#  -O*:       optimization level
#  -f...:     tuning, see gcc manual and avr-libc documentation
#  -Wall...:  warning level
#  -Wa,...:   tell GCC to pass this to the assembler.
#    -ahlms:  create assembler listing
```

```
CFLAGS = -g -O$(OPT) \
-funsigned-char -funsigned-bitfields -fpack-struct -fshort-enums \
-Wall -Wstrict-prototypes \
-Wa,-adhlns=$(<:.c=.lst) \
$(patsubst %,-I%,$(EXTRAINCDIRS))


# Set a "language standard" compiler flag.
#   Unremark just one line below to set the language standard to
use.
#   gnu99 = C99 + GNU extensions. See GCC manual for more
information.
#CFLAGS += -std=c89
#CFLAGS += -std=gnu89
#CFLAGS += -std=c99
CFLAGS += -std=gnu99



# Optional assembler flags.
#  -Wa,...:   tell GCC to pass this to the assembler.
#  -ahlms:    create listing
#  -gstabs:   have the assembler create line number information;
note that
#             for use in COFF files, additional information about
filenames
#             and function names needs to be present in the
assembler source
#             files -- see avr-libc docs [FIXME: not yet described
there]
ASFLAGS = -Wa,-adhlns=$(<:.S=.lst),-gstabs



# Optional linker flags.
#  -Wl,...:   tell GCC to pass this to linker.
#  -Map:      create map file
#  --cref:    add cross reference to  map file
LDFLAGS = -Wl,-Map=$(TARGET).map,--cref



# Additional libraries

# Minimalistic printf version
#LDFLAGS += -Wl,-u,vfprintf -lprintf_min

# Floating point printf version (requires -lm below)
#LDFLAGS += -Wl,-u,vfprintf -lprintf_flt

# -lm = math library
LDFLAGS += -lm



# Programming support using avrdude. Settings and variables.

# Programming hardware: alf avr910 avrisp bascom bsd
# dt006 pavr picoweb pony-stk200 sp12 stk200 stk500
#
```

```
# Type: avrdude -c ?
# to get a full listing.
#
AVRDUDE_PROGRAMMER = stk500


AVRDUDE_PORT = com1        # programmer connected to serial device
#AVRDUDE_PORT = lpt1    # programmer connected to parallel port

AVRDUDE_WRITE_FLASH = -U flash:w:$(TARGET).hex
#AVRDUDE_WRITE_EEPROM = -U eeprom:w:$(TARGET).eep

AVRDUDE_FLAGS = -p $(MCU) -P $(AVRDUDE_PORT) -c
$(AVRDUDE_PROGRAMMER)

# Uncomment the following if you want avrdude's erase cycle counter.
# Note that this counter needs to be initialized first using -Yn,
# see avrdude manual.
#AVRDUDE_ERASE += -y

# Uncomment the following if you do /not/ wish a verification to be
# performed after programming the device.
#AVRDUDE_FLAGS += -V

# Increase verbosity level.  Please use this when submitting bug
# reports about avrdude. See
<http://savannah.nongnu.org/projects/avrdude>
# to submit bug reports.
#AVRDUDE_FLAGS += -v -v




# ------------------------------------------------------------------
---------

# Define directories, if needed.
DIRAVR = c:/winavr
DIRAVRBIN = $(DIRAVR)/bin
DIRAVRUTILS = $(DIRAVR)/utils/bin
DIRINC = .
DIRLIB = $(DIRAVR)/avr/lib


# Define programs and commands.
SHELL = sh

CC = avr-gcc

OBJCOPY = avr-objcopy
OBJDUMP = avr-objdump
SIZE = avr-size


# Programming support using avrdude.
AVRDUDE = avrdude


REMOVE = rm -f
COPY = cp
```

```
HEXSIZE = $(SIZE) --target=$(FORMAT) $(TARGET).hex
ELFSIZE = $(SIZE) -A $(TARGET).elf



# Define Messages
# English
MSG_ERRORS_NONE = Errors: none
MSG_BEGIN = -------- begin --------
MSG_END = --------  end  --------
MSG_SIZE_BEFORE = Size before:
MSG_SIZE_AFTER = Size after:
MSG_COFF = Converting to AVR COFF:
MSG_EXTENDED_COFF = Converting to AVR Extended COFF:
MSG_FLASH = Creating load file for Flash:
MSG_EEPROM = Creating load file for EEPROM:
MSG_EXTENDED_LISTING = Creating Extended Listing:
MSG_SYMBOL_TABLE = Creating Symbol Table:
MSG_LINKING = Linking:
MSG_COMPILING = Compiling:
MSG_ASSEMBLING = Assembling:
MSG_CLEANING = Cleaning project:




# Define all object files.
OBJ = $(SRC:.c=.o) $(ASRC:.S=.o)

# Define all listing files.
LST = $(ASRC:.S=.lst) $(SRC:.c=.lst)

# Combine all necessary flags and optional flags.
# Add target processor to flags.
ALL_CFLAGS = -mmcu=$(MCU) -I. $(CFLAGS)
ALL_ASFLAGS = -mmcu=$(MCU) -I. -x assembler-with-cpp $(ASFLAGS)



# Default target.
all: begin gccversion sizebefore $(TARGET).elf $(TARGET).hex
$(TARGET).eep \
      $(TARGET).lss $(TARGET).sym sizeafter finished end


# Eye candy.
# AVR Studio 3.x does not check make's exit code but relies on
# the following magic strings to be generated by the compile job.
begin:
      @echo
      @echo $(MSG_BEGIN)

finished:
      @echo $(MSG_ERRORS_NONE)

end:
      @echo $(MSG_END)
      @echo


# Display size of file.
```

```
sizebefore:
	@if [ -f $(TARGET).elf ]; then echo; echo $(MSG_SIZE_BEFORE);
$(ELFSIZE); echo; fi

sizeafter:
	@if [ -f $(TARGET).elf ]; then echo; echo $(MSG_SIZE_AFTER);
$(ELFSIZE); echo; fi



# Display compiler version information.
gccversion :
	@$(CC) --version




# Convert ELF to COFF for use in debugging / simulating in
# AVR Studio or VMLAB.
COFFCONVERT=$(OBJCOPY) --debugging \
	--change-section-address .data-0x800000 \
	--change-section-address .bss-0x800000 \
	--change-section-address .noinit-0x800000 \
	--change-section-address .eeprom-0x810000


coff: $(TARGET).elf
	@echo
	@echo $(MSG_COFF) $(TARGET).cof
	$(COFFCONVERT) -O coff-avr $< $(TARGET).cof


extcoff: $(TARGET).elf
	@echo
	@echo $(MSG_EXTENDED_COFF) $(TARGET).cof
	$(COFFCONVERT) -O coff-ext-avr $< $(TARGET).cof




# Program the device.
program: $(TARGET).hex $(TARGET).eep
	$(AVRDUDE) $(AVRDUDE_FLAGS) $(AVRDUDE_WRITE_FLASH)
$(AVRDUDE_WRITE_EEPROM)




# Create final output files (.hex, .eep) from ELF output file.
%.hex: %.elf
	@echo
	@echo $(MSG_FLASH) $@
	$(OBJCOPY) -O $(FORMAT) -R .eeprom $< $@

%.eep: %.elf
	@echo
	@echo $(MSG_EEPROM) $@
	-$(OBJCOPY) -j .eeprom --set-section-
flags=.eeprom="alloc,load" \
	--change-section-lma .eeprom=0 -O $(FORMAT) $< $@
```

```
# Create extended listing file from ELF output file.
%.lss: %.elf
	@echo
	@echo $(MSG_EXTENDED_LISTING) $@
	$(OBJDUMP) -h -S $< > $@

# Create a symbol table from ELF output file.
%.sym: %.elf
	@echo
	@echo $(MSG_SYMBOL_TABLE) $@
	avr-nm -n $< > $@



# Link: create ELF output file from object files.
.SECONDARY : $(TARGET).elf
.PRECIOUS : $(OBJ)
%.elf: $(OBJ)
	@echo
	@echo $(MSG_LINKING) $@
	$(CC) $(ALL_CFLAGS) $(OBJ) --output $@ $(LDFLAGS)


# Compile: create object files from C source files.
%.o : %.c
	@echo
	@echo $(MSG_COMPILING) $<
	$(CC) -c $(ALL_CFLAGS) $< -o $@


# Compile: create assembler files from C source files.
%.s : %.c
	$(CC) -S $(ALL_CFLAGS) $< -o $@


# Assemble: create object files from assembler source files.
%.o : %.S
	@echo
	@echo $(MSG_ASSEMBLING) $<
	$(CC) -c $(ALL_ASFLAGS) $< -o $@




# Target: clean project.
clean: begin clean_list finished end

clean_list :
	@echo
	@echo $(MSG_CLEANING)
	$(REMOVE) $(TARGET).hex
	$(REMOVE) $(TARGET).eep
	$(REMOVE) $(TARGET).obj
	$(REMOVE) $(TARGET).cof
	$(REMOVE) $(TARGET).elf
	$(REMOVE) $(TARGET).map
	$(REMOVE) $(TARGET).obj
	$(REMOVE) $(TARGET).a90
	$(REMOVE) $(TARGET).sym
```

```
	$(REMOVE) $(TARGET).lnk
	$(REMOVE) $(TARGET).lss
	$(REMOVE) $(OBJ)
	$(REMOVE) $(LST)
	$(REMOVE) $(SRC:.c=.s)
	$(REMOVE) $(SRC:.c=.d)


# Automatically generate C source code dependencies.
# (Code originally taken from the GNU make user manual and modified
# (See README.txt Credits).)
#
# Note that this will work with sh (bash) and sed that is shipped
with WinAVR
# (see the SHELL variable defined above).
# This may not work with other shells or other seds.
#
%.d: %.c
	set -e; $(CC) -MM $(ALL_CFLAGS) $< \
	| sed 's,\(.*\)\.o[ :]*,\1.o \1.d : ,g' > $@; \
	[ -s $@ ] || rm -f $@


# Remove the '-' if you want to see the dependency files generated.
-include $(SRC:.c=.d)



# Listing of phony targets.
.PHONY : all begin finish end sizebefore sizeafter gccversion coff
extcoff \
	clean clean_list program
```

APPENDIX B
RF MODULE DATA SHEET
ATMEL ATMEGA8535 BLOCK DIAGRAM

RCT-433-AS / ASB

Low-Cost SAW-stabilized surface mount
OOK RF transmitter

Typical Applications

- Remote Keyless Entry (RKE)
- Remote Lighting Controls
- On-Site Paging
- Asset Tracking
- Wireless Alarm and Security Systems
- Long Range RFID
- Automated Resource Management

Features

- 315/418/433.92 MHz versions
- Low Cost
- 1.5-12V operation
- 5mA current consumption at 3V
- Small size.
- 0dBm output power at 3V
- 4800 baud operation

RCT-433-AS

RCT-433-ASB

Description

The RCT-433-AS is ideal for remote control applications where low cost and longer range are required. The transmitter operates from a 1.5-12V supply, making it ideal for battery-powered applications. The transmitter employs a SAW-stabilized oscillator, ensuring accurate frequency control for best range performance. Output power and harmonic emissions are easy to control, making FCC and ETSI compliance easy. The manufacturing-friendly SMT style package and low-cost make the RCT-433-AS suitable for high volume applications. The RCT-433-ASB is suitable for IR reflow ovens and hot air soldering.

Ordering Information

Frequency	Part Number
433.92 MHz	RCT-433-AS
433.92 MHz	RCT-433-ASB

Domestic and international orders: Mouser Electronics 1-800-346-6873 (http://www.mouser.com)
Future Electronics (http://www.futureelectronics.com)

For a Radiotronix Representative in your area please visit www.radiotronix.com and visit our corporate information page.

Document Control

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Approved - Engineering	**Tom Marks**	**8/21/03**
Approved - Marketing	**Bryan Montgomery**	**8/21/03**

Revision History

Revision	Author	Date	Description
1.1.0	SJM	05/21/02	Document Created
1.2.0	BFA	07/30/03	Revision
1.3.0	SJM	8/21/03	Revision. Added troubleshooting and design tips.
1.4.0	GWH	6/7/05	Added RCT-433-ASB specification to datasheet.

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Pin Out Diagram

Pin Description

Pin No.	Pin Name	Description
1	ANT	50 ohm antenna output. The antenna port impedance affects output power and harmonic emissions. An L-C low-pass filter may be needed to sufficiently filter harmonic emissions.
2	GND	Transmitter ground. Connect to ground plane.
3	DATA	Digital data input. This input is CMOS compatible and should be driven with CMOS level inputs.
4	VCC	Pin 4 provides operating voltage for the transmitter. VCC should be bypassed with a .01uF ceramic capacitor and filtered with a 4.7uF tantalum capacitor. Noise on the power supply will degrade transmitter noise performance.

Mechanical Drawing

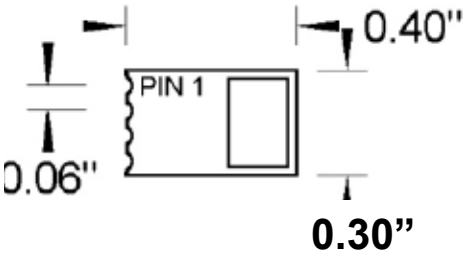


Figure 1: Mechanical Drawing of RCT-433-AS

Figure 2: Suggested Pad Layout

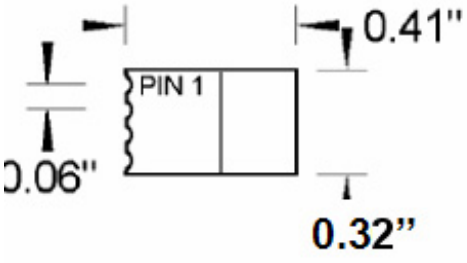


Figure 3: Mechanical Drawing of RCT-433-ASB

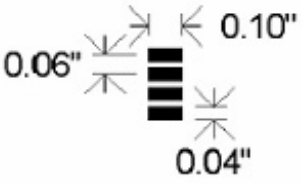


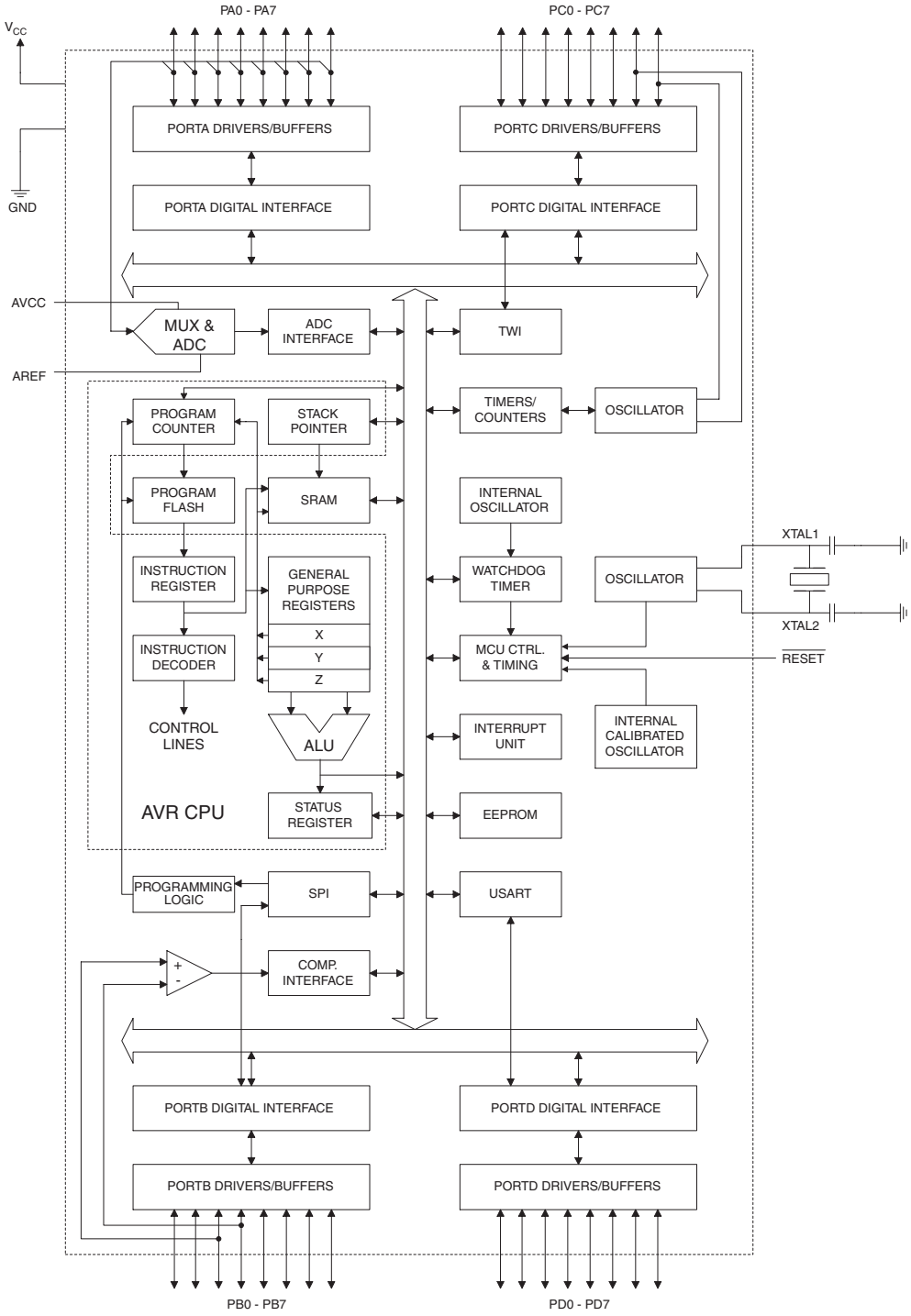
Figure 4: Suggested Pad Layout

Overview

The ATmega8535 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing instructions in a single clock cycle, the ATmega8535 achieves throughputs approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed.

Block Diagram

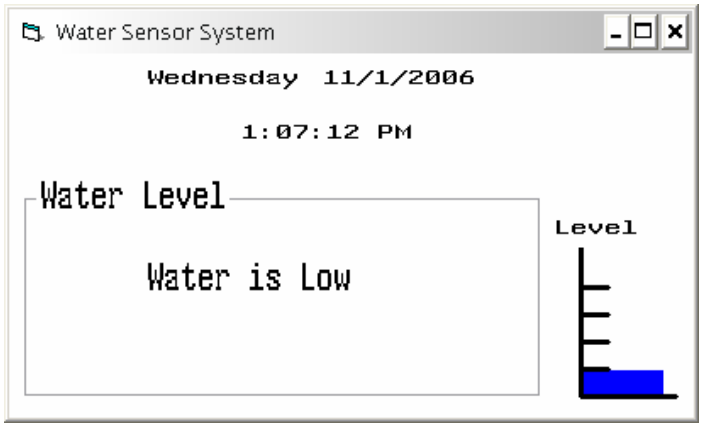
Figure 2. Block Diagram



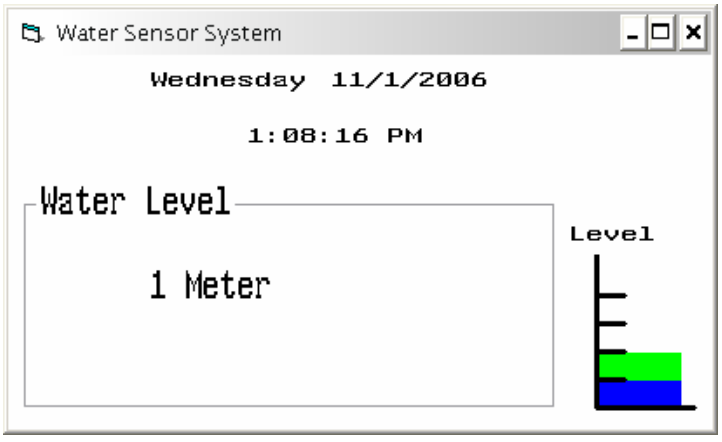
APPENDIX C
RESULT FROM GRAPHICAL USER INTERFACE

Result from Graphical User Interface

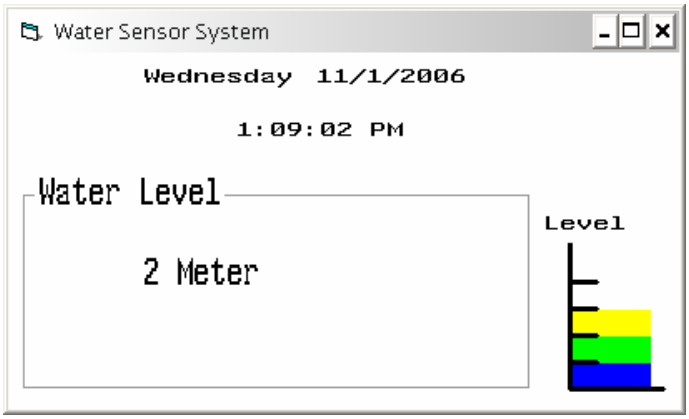
When the sensor did not sense any water, it considers as low water level. Therefore the first level is assigned with blue color. The message also wills popup in the "water level" section. Then when the sensor sense the first level of the water, the second level in GUI will assign green color. This process will continue until the water reached the highest level where the message "4 meter (critical) will appear on screen. The following figures have summarized the operation of GUI for this system.



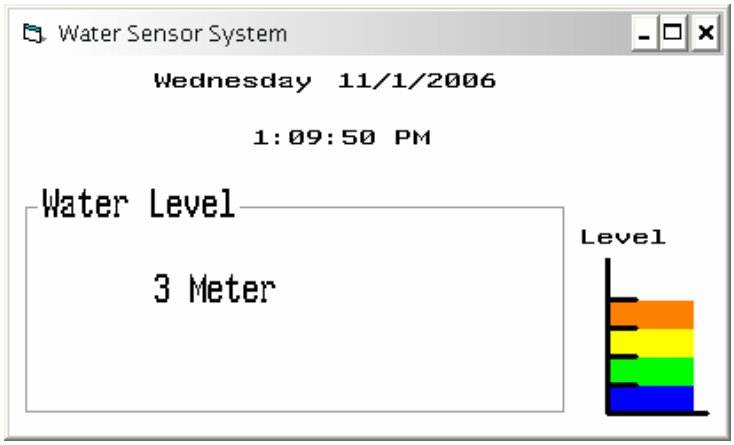
(a)



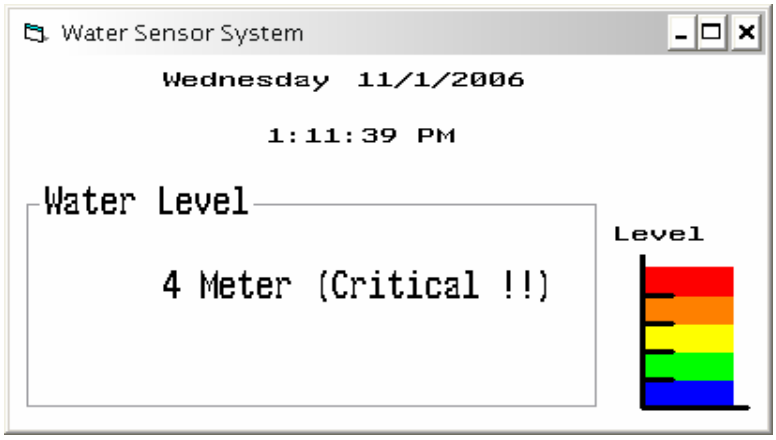
(b)



(c)



(d)



(e)

GUI result: (a) No level, (b) Level 1, (c) level 2, (d) level 3 and (e) level4

APPENDIX D
PONYPROG MANUAL

How to use PonyProg2000 for the Microrobot AVR Products(Rev 0.3)

Contents

What is PonyProg2000?
How to install?
Preparation
How to download a program using PonyProg2000

What is PonyProg2000?

PonyProg is a serial device programmer software with a user-friendly GUI framework available for Windows95, 98, 2000 & NT and Intel Linux. Its purpose is reading and writing every serial device. At the moment it supports I²C Bus, Microwire, SPI EEPROM, the Atmel AVR and Microchip PIC micro.

For more details, visit http://www.lancos.com/e2p/ponyprog2000.html

How to install?

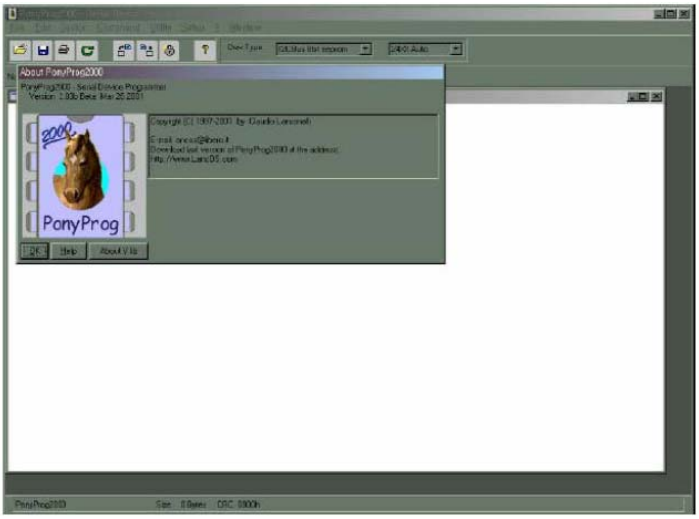
Run the setup.exe file.

Preparation

1. Supply proper power to the (CPU) board.
2. Connect the downloading adapter to the PC printer port. Then connect the downloading adapter and the board with the flat cable.
3. Turn on the power switch on the board. Power LED turns on (when applicable).
4. Compile the source file you want to download.

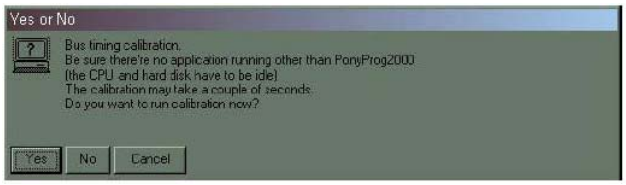
How to download a program using PonyProg2000

Run the PonyPorg2000 program.



Click on OK. The following window appears.

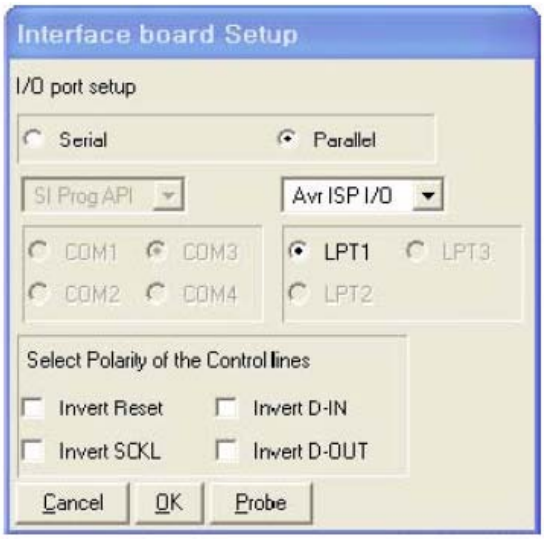
Click on OK. Select 'Setup → Calibration'.


Yes or No
Bus timing calibration.
Be sure there're no application running other than PonyProg2000
(the CPU and hard disk have to be idle)
The calibration may take a couple of seconds.
Do you want to run calibration now?
Yes
No
Cancel

Click on Yes button. The following window appears.

Click on OK.

Select 'Setup → interface Setup' and set up as shown below (Parallel, Avr ISP I/O, LPT1) and click on Probe. 'Test Ok' message appears. Click on OK. Click on OK.



Select the device you want. (‘Device → AVR micro → XXX’, XXX is the device you want)
Select ‘Command → Program Options’ and check as shown below. (Reload Files, Erase, Write Program memory)
Click on OK.

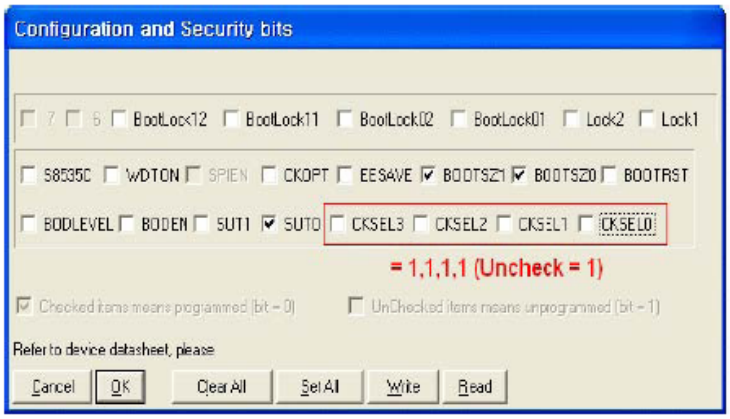
Some devices require ‘Flash Fuse Bits Setting’ for the desired clock source setting. For example, CKSEL3..0 bits of the ATmega8535 and Atmega8515 devices need to be set 1 to

select the External Crystal clock source mode. Refer to ‘Clock Options’ of the device sheet for the detailed bit setting.

If you need to set the bits, select ‘Command → Security and Configuration Bits…’.

Click on Read button, uncheck the CKSEL3..0 bits and then click on Write button.

Fig 1.6 shows a ‘Security and Configuration Bits’ dialog box as an example.



Note: If the board has an AT90S-type CPU instead of ATmega-type, the setting is not required.

Select ‘File → Open Program File’ and load the *.rom(or *.hex) file.

Select ‘Command → Program’ or press ‘Ctrl + P’ to start the downloading. If no ‘Program Failed’ message appears, the downloading has been completed successfully.